DEPARTMENT OF EARTH AND ENVIRONMENTAL SCIENCES
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ANNUAL DISSERTATION TOPIC LIST

(ORALS PASSED THROUGH AUTUMN ´17)

NATALIE ACCARDO

Date Orals Passed: 5/15
Advisory Committee: Gaherty, Shillington, Ekstrom

Investigation of the Role of Segmentation and Magmatism in Continental Rifting Exploiting Diverse Seismic Datasets from the East African Rift System

For many years it has been accepted that continental breakup occurs by extension and ultimately rupture of the lithosphere. However, the emergence and early evolution of two fundamental characteristics of divergent plate boundaries, segmentation and magmatism, are not well understood because most studies focus on mature or successfully rifted margins. Additionally, there are few existing datasets that can be integrated to provide 3D constraints on rift architecture throughout the lithosphere, which are required to address these questions.

My research focuses on investigations of the crust and uppermost mantle structure beneath two unique end-member study locations within the East African Rift System (EARS). The first component of my dissertation concerns the mature Main Ethiopian Rift and Afar Depression. I used earthquake and continuous data from 100+ temporary seismic stations located in the region to investigate the shear velocity and radially anisotropic structure of the uppermost mantle. This investigation produced estimates of mantle temperature and melt content within the rift and also highlighted the potential location of melt segregation along a steeply dipping lithosphere-asthenosphere boundary.

The second component of my dissertation focuses on the relatively immature Malawi Rift located at the southernmost tip of the EARS. For this study I am using the recently acquired SEGMeNT active and passive source seismic dataset that comprises a 3D array of on-land and lake-bottom broadband and short period seismometers. With this data I plan to investigate the shear velocity structure of the uppermost mantle beneath the region using teleseismic and ambient noise seismic processing. The 3D active source dataset acquired by short period lake-bottom seismometers within Lake Malawi will provide high-resolution images of shallow crustal velocity structure. Together these diverse datasets will yield novel constraints on the state of the Malawi Rift and the role of segmentation and magmatism in an immature continental rift setting.

GULEED ALI

Date Orals Passed: 4/13
Advisory Committee: Hemming, Christie-Blick, Broecker

My dissertation work is focused on constraining a Last Glacial Maximum and deglacial record of hydroclimate change from the Mono Basin, California. The emphasis of my work is on sedimentary and stratigraphic observations that I use to interpret lake level fluctuations--a proxy for changes in the basin's precipitation minus evaporation balance. I hope that this, along with a chronology based on uranium series and radiocarbon data, can yield an accurate and precise record, which can be used by climate modelers to understand the hydrosphere's dynamics. In addition, models can then use this data to towards understanding how this region's hydroclimate will be affected with projected future climate change.

ALEXANDRA BAUSCH

Date Orals Passed: 5/14
Advisory Committee: A. Juhl, B. Anderson, H. Ducklow

Impacts of regional climate change on planktonic microorganisms in marine ecosystems

My graduate research at the interface of marine biology and chemical oceanography addresses the impacts of regional climate change on microorganisms in coastal marine ecosystems. Much of my research focuses on the effects of multiple stressors on the growth and physiology of planktonic microorganisms, which form the base of the marine food web and serve as some of the first bioindicators of change in marine ecosystems. Although the effects of ocean acidification are known for some marine plankton, the interactive effects of ocean acidification and other chemical stressors (e.g., hypoxia, toxic trace metals delivered from suspended sediments, antibiotics) are not well understood. Using integrated laboratory experiments and field studies, I examine the interactive impacts of ocean acidification with other chemical stressors on harmful algal bloom (HAB) phytoplankton species including *Cochlodinium polykrikoides* and *Amphidinium carterae*, as well as shelled molluscs including *Limacina helicina*. In addition, some of my research focuses on the supply of dust – a major source of iron for phytoplankton – in surface waters of the Indian Ocean. Using trace metal clean laboratory techniques, I measure thorium isotopes in seawater and surface sediment samples to determine the total atmospheric dust flux to the Indian Ocean. These interdisciplinary studies address the coupled biological and chemical changes in marine ecosystems as a result of increased anthropogenic climate change.

TARINI BHATNAGAR

Date Orals Passed: 4/14
Advisory Committee: Tolstoy, Goldberg, Malinverno

Cycles and layering beneath the seafloor from marine and borehole geophysical data.

In my first chapter, I examine the effect of short-term tidal cycles in the ocean. Specifically, I assess triggering of seismic activity related to the true fortnightly and fortnightly modulations of diurnal and semidiurnal tides at the East Pacific Rise through a dataset from an Ocean Bottom Seismometer array that was deployed from October 2003 to January 2007. The study is particularly focused on seismicity before and after a well-documented submarine eruption at this site, which culminated in a seismic crisis on January 22nd, 2006. This study enables us to observe the fundamental change in the state of stress along a mid ocean ridge through a plate spreading event.

For my second and third chapter, I am looking at the morphology, origin and evolution of Pleistocene submarine canyons at the New Jersey margin. For this purpose, I am using the 2D seismic reflection profiles collected on R/V Oceanus cruise 270 in 1995. Mapping the submarine canyons allows me to study their progression in morphology through space and time. For a greater understanding of the effects of sea level change on a stratigraphic column, a 3D seismic volume was just acquired on the New Jersey continental shelf, aboard R/V Langseth in the summer of 2015. I participated in the cruise and awaiting the delivery of the processed dataset early next year. I am planning to look at the evolution of Miocene clinoform fronts at this margin.

In my last chapter, I am going to evaluate the ocean crustal sites at Reykjanes ridge, offshore Iceland for carbon dioxide sequestration in layers of deep-sea basalt. This work aims to look for an offshore extension of the onshore CarbFix project launched in 2007. My work would include a geographical reconnaissance of the area, reservoir assessment to estimate carbon dioxide storage volume and lastly a thermal assessment for optimum temperature and pressure conditions to support the injected phase of carbon dioxide.

ALEJANDRA BORUNDA

*Date Orals Passed***:** 1/14
*Advisory Committee***:** Winckler, Goldstein, Kaplan

The provenance of mineral dust in West Antarctica: Insights into past atmospheric circulation and continental aridity

Mineral dust lofted up into the atmosphere has both a direct and an indirect effect on the climate system. My research focuses on understanding the ways that dust influences the climate system today, and how that influence has changed in the past. In particular, we can use dust as a tracer of past atmospheric circulation patterns: by comparing the radiogenic isotopic "fingerprint" of places where the dust might have come from with the signal we see in some climate archive, we know that storm systems transported that dust from that known source to our location of interest. Then, we can see how the source areas may have changed over time.

My samples come from several ice cores in West Antarctica (WAIS), and we use Sr, Nd, and Pb isotopes to identify the changing dust sources to WAIS on glacial-interglacial and millennial timescales, as well as during even shorter-term events such as volcanic eruptions.

LOGAN BRENNER
Date Orals Passed: 4/15
Advisory Committee: Linsley, deMenocal, B. Anderson

Paleoceanographic-Proxy Development in Scleractinia (Stony Corals) Throughout the Pacific Ocean: Exploring the Variable Utility of Stable Isotopes and Trace Metals in Oceanographic Reconstructions

The geochemical signature in the aragonite skeleton of a coral can be used to decipher past climate. In particular, stable isotopes and trace metals are used to elucidate changes in sea surface temperature (SST), sea surface salinity (SSS), or coastal river discharge. My dissertation research is a compilation of projects aimed at fine-tuning and exploring the bounds of coral paleoceanographic proxies.

Using stable oxygen isotopes from corals off the Pacific coast of Panamá I am reconstructing decadal precipitation patterns to better understand low frequency variability in the Pacific Basin. In conjunction with the precipitation record, I am studying the viability of coral Ba/Ca as a terrestrial run off proxy in the same region to better understand the impacts of oscillating precipitation in the Eastern Tropical Pacific. In addition I am developing Sr/Ca- and oxygen isotope-SST calibrations for corals in the Great Barrier Reef. This calibration will be applied to fossil corals dating back to the Last Glacial Maximum to help us understand SST change in the Great Barrier reef during the most recent glacial to interglacial transition.

Ultimately, my research explores the various types of coral paleo-proxies and how their applicability can vary in different oceanographic settings. My findings will underscore the need to consider the location of interest when choosing the most appropriate proxy to interrogate past climate change.

SOPHIA BRUMER
Date Orals Passed: 4/13
Advisory Committee: Zappa, Gordon, Sobel

My research focuses on air-sea interaction. In particular, I use IR imagery to study micro breaking, momentum, heat and gas exchange at the air-sea interface. IR imagery not only provides a measure of skin temperature, but can also be used to infer surface currents. Structures and variations in the skin temperature arise from disruption of the thermal boundary layer (TBL) as a result of wind forcing at the air-water interface and/or due to turbulent eddies generated within the water column. The TBL makes up top few micro meters of the water column and the key intermediate between the ocean and atmosphere, which plays a crucial role in heat and gas exchanges. My studies aim to infer subsurface and bulk water column characteristics such as turbulent kinetic energy dissipation, and water depth from non-intrusive surface measurements of the thermal boundary layer. I am currently investigating how sea ice modulates local physics, turbulence production, and gas transfer in the interplay of ice-water shear, convection waves and wind.

JULIUS BUSECKE
Date Orals Passed: 10/13
Advisory Committee: Gordon, Thurnherr, Abernathey

Understanding the global freshwater cycle is of tremendous importance in order to understand and adapt to future climate change. The ocean is inherently linked to the global freshwater cycle. Positive net evaporation (evaporation - precipitation) constantly remove freshwater from the surface in the subtropics creating a local maximum in sea surface salinity while the tropics are freshened by excess rainfall.
To balance the loss in freshwater in the subtropics, ocean processes need to mix in surrounding waters laterally and vertically. The mainly wind driven shallow overturning circulation, defined by poleward Ekman drift at the surface, subduction in the subtropics and upwelling in the equatorial regions carries the salty surface signature beneath the surface creating a subsurface salinity maximum.

Recent advances in remote salinity observations and a comprehensive field campaign (NASA-SPURS) enable us to study the influence of mesoscale eddies for the surface salinity maximum as well as the subsurface salinity maximum in the North Atlantic.
My dissertation aims to quantify the importance of mesoscale turbulence to the surface salinity maximum in the North Atlantic and identify links to large scale climate variables using a mix of observational data and simplified model experiments. Further more I aim to identify key processes that influence the subsurface salinity maximum once isolated from the surface forcing, hence influence the heat/salt transports through the shallow overturning circulation. Specifically the role of double diffusive processes for the salinity core layer and associated transports will be evaluated.
Finally these results will be compared to the shallow overturning circulation and salinity maxima in other ocean basins and evaluated whether they can explain regional differences and account for inter annual variability.

CHEN CHEN
Date Orals Passed: 4/11
Advisory Committee: Cane, Ting, D. Chen

Integrated evolution of the atmosphere-ocean coupled modes

El Niño and the Southern Oscillation (ENSO), Pacific Decadal Oscillation (PDO), and Atlantic Multidecadal Oscillation (AMO) are a few significant modes of climate variation from interannual to multidecadal time scales identified from sea surface temperature (SST). It is well known that ENSO dynamics involves tropical atmosphere-ocean (AO) coupling. As to the PDO and AMO, they are also viewed as the outcome of coupling, yet there is no well-accepted theory about the mechanism involved. Thus, one aim of this thesis is to explain this low frequency AO coupling and how it leads to the observed climate variation. Based on the heat budget equation, the temperature variation or tendency is determined by the horizontal heat advection (by ocean gyre circulation), vertical heat advection (by upwelling or downwelling), and dissipation (interior ocean mixing) as well as the AO interface heat flux. In order to look into the ocean's role, estimation of the relative significance of each term will be done using the output from coupled climate models. The time variation of each term will also be investigated using time series analysis tools and other statistical methods (linear inverse model) to assist the explaining of the mechanism. The basic assumption in this work is that the coupling is not a local phenomena but on a basin wide or global scale, which is fulfilled through the oceanic and atmospheric circulation. By studying this topic, we attempt to understand the fundamental question of how heat is transported through AO coupling within the climate system. Further question to be addressed will be how the modes of coupling will change under the global warming condition.

JIANYE CHEN
Date Orals Passed: 4/12
Advisory Committee: Norell, Meng, Flynn

Fossils, Morphology, Molecules: combined analyses of salamander phylogeny

Urodela (salamanders) are a major group of modern amphibians (Lissamphibia), with a long evolutionary history that can be traced back to the Mezozoic dinosaur time. Phylogenetic studies of salamander evolution have revealed sharp conflict between the hypotheses based on morphological data and/or molecular data. The proposed research intends to conduct combined

analyses incorporating phylogenetically significant early fossil taxa, all available morphological and molecular data; a method herein termed “Fossils-Morphology-Molecular Approach” (FMM approach). Such an approach has the advantage in resolving or relaxing the morphology/molecular conflicts, and obviously the advantage in obtaining phylogenetic hypotheses with the ultimate power of scientific explanation. Fossil discoveries from the Middle Jurassic to Early Cretaceous beds in northern China have provided the key material for understanding the origins and early evolution of modern salamander clades. The fossil material found includes the earliest known fossil record of two major salamander clades (Cryptobranchoidea and Salamandroidea), and the basal taxa of several modern salamander clades. These fossils, together with other Mesozoic fossils worldwide, not only increase the taxon sampling for the phylogenetic analysis to be conducted, but also represent new combinations of anatomical characters, many of which are ancestral to salamander evolution. Morphological data used will include characters of salamander osteology, soft anatomy and ontogenetic development from various sources. Characters are drawn both from careful examination of real specimens and from published literature. Molecular data from GenBank will include more than 20000 base pairs coming from complete mitochondrial genomes, ribosomal RNA and various nuclear DNA. These data will be analyzed both separately and combined. Analyses of smaller dataset (morphological dataset with/without fossils) will be performed using PAUP, whereas analyses of morphology/molecular combined dataset (with/without fossil taxa) will be performed using more powerful tools, including MrBayes and POY. Phylogenetic results of parsimony analysis will be compared with that of Maximum Likelihood and Bayesian analysis. Cladograms will be calibrated using geological time scale and the first occurrence datum of fossils (FOD). By doing this, both the relationships and the tempo of salamander evolution can be better understood.

WING YIN CHU
Date Orals Passed: 3/13
Advisory Committee: Bell, Buck, Nettles

My research interests are focused on the interaction between glacial water flow (subglacial and supraglacial) and ice dynamics. Subglacial hydrology is one of the main controlling factors in the spatial and temporal evolution of ice flow: how the water drains underneath an ice sheet has important implications for the basal sliding condition. However, subglacial water drainage is dynamic in space and time and varies in a complicated manner coupled to surface hydrology. Despite recent conceptual advances, relatively little is known about how the surface hydrology interacts with the subglacial drainage system and how it affects effective pressure and ice flow. Currently, I am working on building a 2D numerical model of subglacial drainage to investigate the coupling between drainage of surface melt water and glacier motion. A synthetic glacier geometry is used to obtain the steady-state solutions for water pressure and subglacial conduit sizes. The water pressure solution is applied to a sliding law to calculate ice flow speed. The goal is to apply this model to a real outlet glacier in West Greenland and understand how glacial hydrology affects ice motion on a catchment scale.

OLIVIA CLIFTON
Date Orals Passed: 4/16
Advisory Committee: Fiore, Griffin, Seager

Olivia’s research aims to quantify how tropospheric ozone, an air pollutant and potent greenhouse gas, responds to changing precursor emissions, climate, and land use. In particular, her research focuses on how the vegetation sink of tropospheric ozone changes with meteorology and biophysics and how this modulates atmospheric composition. Olivia uses measurements and a hierarchy of models from the process level to the global scale in her research. Better constraints on spatiotemporal variability in this poorly understood sink and its impact on atmospheric chemistry will advance our ability to predict land-atmosphere interactions in a changing climate.

ELLEN CRAPSTER-PREGONT
Date Orals Passed: 4/13
Advisory Committee: Ebel, Walker, Plank

Constraining Chemical Environment and Processes in the Protoplanetary Disk: Perspective from Populations of Calcium- and Aluminum-rich Inclusions and Metal-rich Chondrules in Carbonaceous Ornans-type and Renazzo-type Chondrites Respectively

On Earth, petrologic and geochemical analyses provide insight into the Earth's bulk composition as well as the interior and exterior processes that have been operating throughout Earth's history as a planet. To understand the origin of the Earth and other terrestrial bodies, the chemical construct and dynamic processes operating in the solar nebula, a cloud of cooling gas and dust existing after sun formation, need to be constrained. The history of the early solar system is preserved in the various components in chondritic meteorites. Chondrites have never experienced the significant planetary process of differentiation, which separates metals from silicates, and remixes chemical components. Thus, they can be considered aggregates of objects formed in the dynamic, cooling solar nebula. Ca- and Al-rich inclusions (CAI) are some of the highest temperature solids formed and preserved in chondrites. Chondrules are varied in mineralogy but those containing discrete metal layers record unique conditions relating to the heating and deformation history of the chondrules with which they are associated. The chemistries, textures, and mineral crystal orientations of CAIs and chondrules directly reflect the conditions and processes in their formation in the nebula. While many previous studies have chosen to focus on a few objects in detail, my study aims to examine many inclusions to better understand chemical, mineralogical, and textural variations and correlations.

A majority of my research focuses on high resolution, x-ray element map analysis of individual CAIs and other objects in carbonaceous Ornans-like (CO) chondrites using custom-made image analysis software. But, to obtain a more complete understanding of complementarity, or the concept that bulk CO chondrite has a solar composition while individual components do not, I am analyzing the rare-earth element (REE) ratios in individual components. Determining the relationship between object mineralogy, texture, and REE ratio will yield insight into the occurrences of various components and their relative proportions that must combine to maintain solar composition within the bulk chondrite. This broad survey of CAIs and other objects in CO chondrites will help constrain astrophysical models, refine the order in which minerals condense from the solar nebula, and further improve the formation criterion necessary to produce the observed variation.

Chondrule formation hypotheses are many but poorly constrained. The chondrules in carbonaceous Renazzo-type (CR) chondrites have associated metal in both the chondrule core and near the rim. Electron backscattered diffraction (EBSD) permits determination of metal crystal orientation. Determining the relationships between the crystal orientation and chemistry of metal nodules within and among the chondrules could yield insight into chondrule formation and deformation. Altogether, the results of this thesis work will contribute to our understanding of our solar system as solids began to form and the journey these solids took before becoming asteroids or planets.

CATHLEEN DOHERTY
Date Orals Passed: 4/12
Advisory Committee: Class, Goldstein, Hemming

Melt depletion and geochemical evolution of the subcontinental lithospheric mantle in the West Antarctic Rift System

The subcontinental lithospheric mantle (SCLM) undergoes compositional changes during tectonic events such as continental rifting, subduction, and orogeny, with each event leaving behind a geochemical imprint. Geochemical mapping of the lithosphere allows us to gain a better understanding of how the continents are structured, and enables us to piece together the tectonic evolution of the continents. Here we look at the Western Ross Sea area of the West Antarctic Rift System (WARS) as a case study.

My thesis focuses on using these geochemical imprints to unravel the geochemical and tectonic evolution of the SCLM in the WARS:

Os isotope ratios can be used to date the melt depletion events in the asthenosphere that are considered to be equivalent to the stabilization age of the lithospheric mantle. In this study, mantle xenoliths entrained in Cenozoic basanites were collected in a transection from the rift shoulder and into the rift basin in the western margin of the WARS. Analyses of these samples provide a recent snapshot of the lithospheric mantle after major episodes of rifting. If we can trace the age of the lithospheric mantle across this margin, we can begin to understand its behavior in response to rifting and subsequent structure. We repeatedly observe ~1.7 Ga depletion events across the rifted margin, indicating the widespread Paleoproterozoic stabilization of the lithosphere and dynamic thinning of lithosphere across the western margin of the WARS.
Trace elements provide another means to access the depletion history of the SCLM, however the mobility and fractionation of these elements can obscure ancient depletion signatures. Nevertheless, we can exploit the behavior of these trace elements. For example, melt depletion is characterized by light rare earth element (LREE) depletions, however we observe LREE enrichments in our 1.7 Ga xenoliths. Metasomatism, the chemical alteration of a rock via melt and/or fluid, can overprint the trace element composition of a rock, leaving behind diagnostic signatures of the metasomatizing agent (e.g. LREE re-enrichment by a carbonatitic melt).
Sr-Nd-Hf-Pb isotopes can be used to constrain the role of the SCLM in the formation of WARS volcanism. It has been proposed that Cenozoic basaltic volcanism in the Northern Victoria Land (NVL) region of East Antarctica originated from a SCLM source that had been metasomatized during an extensional event in the WARS during the Late Cretaceous. Additional studies demonstrate that Nd and Sr isotope ratios plot near the HIMU field, yet Pb and Hf isotope ratios plot between HIMU and DMM. This can be accounted for by varying proportions of lithospheric mantle source that has experienced Paleozoic to Mesozoic modification due to subduction related fluids and flux melting which can incorporate fluid mobile elements such as Pb from the mantle wedge. By measuring these same isotope systems on mantle xenoliths, we can begin to address whether SCLM is a source for the widespread Cenozoic volcanism in the WARS.

ETIENNE DUNN-SIGOUIN
Date Orals Passed: 4/14
Advisory Committee: Shaw, Seager, Ting, Polvani

Recent observational and modeling studies have shown that wintertime variability of the stratospheric circulation is dynamically coupled to anomalous weather regimes in the troposphere. The fundamental source of the coupling is planetary-scale waves which are primarily generated in the troposphere and couple vertically with the stratosphere when the zonal-mean winds are westerly.

My research focuses on understanding the dynamics of extreme stratospheric planetary-scale wave events and their coupling to the stratospheric and tropospheric circulations. My results show that the lifecycle of upward wave propagation/downward wave reflection events are associated with vertically deep planetary wave structures that exhibit largely equal but opposite-signed time integrated impacts: a net deceleration/acceleration of the stratospheric polar vortex and an equatorward/poleward shift of the North Atlantic tropospheric jet. Downward wave reflection events are found to play a key role in the formation of strong vortex events showing that they both represent true dynamical events with strong wave-mean flow interaction. Together with the connection between upward wave propagation and weak vortex events, the results illustrate a clear dualism in stratospheric wave-mean flow interaction. Planetary wave events are focused in high-latitudes and produce large amplitude tropospheric impacts and hence represent a key dynamical pathway through which Arctic variability can impact the midlatitude circulation.

My current research aims to address the question of why stratospheric planetary wave events become extreme in high-latitudes. Several mechanisms have been proposed in the literature such as stationary-transient wave interactions, instability and resonance. A better understanding of the dynamical mechanisms responsible for planetary wave events is the subject of current research using idealized modeling.

CELIA EDDY
Date Orals Passed: 4/15
Advisory Committee: Ekstrom, Gaherty, Nettles

Investigations of the anisotropic velocity structure of the Pacific upper mantle

Seismic anisotropy, the variation of seismic velocity with the propagation or polarization direction of a wave, is an important observable for investigating the dynamics of the interior of the Earth. Models of seismic anisotropy in oceanic regions provide information about the geometry of strain and flow in the mantle, the specific nature of the lithosphere-asthenosphere boundary, and the possible presence of partial melt in the asthenosphere.

In order to investigate these and other questions, my research is focused on developing a three-dimensional model of the anisotropy velocity structure of the Pacific upper mantle. Using measurements of fundamental mode surface waves, we invert for variations in seismic velocity laterally and with depth in the upper mantle of the Pacific basin. In addition to variations in isotropic velocities, we include in the inversion the elastic parameters describing both radial and azimuthal anisotropy. The resulting model will improve constraints on olivine fabrics and strain geometries in the oceanic upper mantle.

ZACHARY EILON

Date Orals Passed: 3/13
Advisory Committee: Abers, Gaherty, Buck

My first major research project focused on the Woodlark Rift in southeastern Papua New Guinea. This is one of the youngest and most rapidly extending continental rifts in the world, and is an intriguing locality for investigating how continents break apart. The D'Entrecasteaux Islands, at the heart of this rift, comprise metamorphic core complexes that contain the world's youngest ultra-high pressure coesite eclogite, exhumed from 100 km depth in just 5 Ma. I have applied a variety of seismological techniques to investigate this region, using data from a temporary array of broadband seismometers installed by members of the LDEO seismology dept. that ran from 2010-2011.

My analysis of shear-wave splitting, using core-traversing teleseisms, shows strong anisotropy beneath this rift, attributed to crystallographic fabric in the shallow mantle caused by the rate and extent of continental rifting. I have related anisotropy and shear strain in the shallow convecting mantle to predict shear-wave splitting times that are very close to the splitting times I observe, bolstering our hypothesis that the anisotropy arises from mantle fabric related to rifting. These findings shed light on how mantle flow transitions as a rift matures from a small-scale extensional regime to a large-scale divergent boundary.

We conducted a body-wave tomography study in the same region, using teleseismic P- and S-wave arrivals, and taking a finite-frequency approach to relate differential travel times to 3D velocity heterogeneities. The isotropic velocity model reveals a localised rift structure evident to ≥180 km depth, as well as an apparent slab remnant that contains the first intermediate depth seismicity observed in this region, discovered last year by members of our research group. Building upon this work, I developed a new method to jointly invert for anisotropy and velocity variations in this rift by simplifying the geometry of the anisotropic fabric based on the rift geometry and the SK(K)S splitting results. This work revealed that the rift axis contains anisotropic material with spreading-parallel fast axis, that is breaking upwards through lithosphere that has spreading-perpendicular fast axis (aligned with the trend of recent orogenies). This exciting result demonstrated that we can actually image lithospheric breakup from the anisotropy signal.

My next project will entail a change in direction: we are using OBS and on-land seismic data from the Cascadia Initiative's Amphibious Array to study attenuation of the Juan de Fuca plate from ridge to trench to arc. Using differential t* measurements we can investigate the variation of attenuation associated with plate ageing to answer questions about the plate's thermal structure, the distribution of melt/volatiles, and the fate of the asthenosphere upon subduction. This work complements previous studies using surface waves and will contribute to our developing understanding of anelastic controls on seismic parameters by probing the Earth in a different frequency range.

JESSE FARMER

Date Orals Passed: 4/14
Advisory Committee: Hönisch, McManus, deMenocal

Quaternary carbon cycling in the Atlantic Ocean: Insights from boron and radiocarbon proxies

Ice core records of atmospheric carbon dioxide (CO2) support a tight linkage between CO2 concentrations and climate over Quaternary glacial-interglacial cycles. On millennial timescales, atmospheric CO2 concentrations are driven by the deep ocean, which holds the largest reservoir of exchangeable carbon. The nature and phasing of relationships between deep ocean circulation, the oceanic carbon cycle, atmospheric CO2 and climate remain enigmatic, and are all the more important considering recent anthropogenic perturbation of the global carbon cycle.

My research addresses the above questions through the creation of new paleoproxy records to constrain deep-ocean carbon cycling. To date, I have measured the boron isotope and radiocarbon composition of deep-sea bamboo corals, and assessed their ability to record changing pH and radiocarbon activity in the North Atlantic Ocean. Going forward, I aim to combine radiocarbon records from modern deep-sea corals to elucidate the transfer of radiocarbon produced by nuclear weapons testing to the deep North Atlantic Ocean. Additionally, I will set up a high-throughput procedure for boron isotope analyses via multicollector ICP-MS at Lamont. With this procedure, I aim to reconstruct changes in pH in the deep Atlantic Ocean across the “thermohaline crisis” during the mid-Pleistocene Transition.

CHLOE Y. GAO
Date Orals Passed: 4/16
Advisory Committee: Tsigaridis, Bauer, Fiore

The goal of my research is to investigate the impact of organic aerosol volatility on aerosol microphysics project by including the condensation and evaporation of organic aerosols in an aerosol microphysics model. I implemented the volatility-basis set (VBS) framework into an aerosol microphysical scheme MATRIX (Multiconfiguration Aerosol TRacker of mIXing state), which resolves mass and number aerosol concentrations and aerosol mixing state. The new scheme, MATRIX-VBS, is unique and advances the representation of organic aerosols in Earth system models (ESMs) by greatly improving the traditional and very simplistic treatment of organic aerosols as non-volatile and with a fixed size distribution. Such treatment is important, because low-volatility organics contribute significantly to the growth of small particles into climate-relevant sizes, while the condensation of organic vapors on pre-existing particles can alter their chemical, physical and optical properties, with important implications on climate. The new scheme is developed in a box model, aiming to understand at the process level under which conditions the model’s results are significantly affected [*Gao et al.*, 2017]. The new scheme is being simplified and evaluated against the detailed one based on Monte Carlo type simulations that cover all possible atmospheric conditions. The simplified version of the box model will then be implemented in the NASA GISS ModelE. This project will bridge the scales between aerosol microphysical processes and global climate, and it will provide an improved and a more realistic version of the microphysical aerosol scheme used in the NASA GISS ModelE.

JAMES GIBSON
Date Orals Passed: 5/15
Advisory Committee: Shillington, Tolstoy, Carbotte

Controls on surface processes, fluid flow, sedimentation, and faulting on active and passive margins from multi-beam sonar and multi-channel seismic reflection data.

My thesis will include at least three chapters:

The first chapter is focused toward gaining an understanding of surface processes, fluid flow, faulting/compaction, and sediment physical properties outboard of the deformation front at the Cascadia Subduction Zone. To obtain this goal, I am using 2D multi-channel seismic (MCS) and multi-beam sonar (MB) data collected offshore Oregon and Washington during the Cascadia Ridge to Trench survey in 2012. I first performed detailed p-wave velocity analysis to achieve sub-surface perspective on seafloor surface related fluid flow features (e.g. pockmarks). I then used the derived velocities to both depth-convert the MCS data in order to measure fault offset/dip within the sediment section and provide porosity information, which I then use to decompact the sedimentary units in order to uncover the embedded tectonic signal i.e. intra-plate

faulting. As an additional project, I mapped large-scale scour marks on the distal Astoria Fan and then inverted for the source process azimuth. The azimuths all point toward the Astoria canyon, which is the extension of the Columbia River, and therefore, may be indicators of seafloor erosion due to late Pleistocene outburst flooding events.

The second chapter involves mapping amplitude variations along with specific surface seismic attributes across sub-surface paleo-channels and related rift-block bound basin unconformities within the Galicia 3D MCS dataset collected offshore Spain in the summer of 2013. The 3D volume is ~20km x 67km and has been processed to pre-stack time migration. I am then relating the amplitude variations/surface seismic attributes to current seafloor reflectivity derived from the MB backscatter data in order to better constrain channel morphology and abyssal plain sand distribution as it relates to tectonic and climatic forcing processes from the Miocene to present. Furthermore, I plan to use the drilling results/check-shots to generate synthetics in order to better constrain the time-depth relationship indicated by the reflectivity series.

The third chapter will involve 2D MCS and MB data collected offshore the US East coast during both the ENAM & USGS/NOAA surveys in 2013-2015. I will develop a 1D inversion algorithm to constrain the p-wave velocities and use them to study the physical properties of discrete Holocene submarine slope failures. Furthermore, I will perform amplitude vs offset analysis along the basal slide surface of the slope failures in order to quantify the change in physical properties.

YONATON GOLDSMITH

Date Orals Passed: 4/14
Advisory Committee: Broecker, deMenocal, Polissar

Investigating:

Variation in the intensity of the East Asian Summer Monsoon as recorded by elevated shorelines and dD leafwax

- dD leafwax in soils

- Water isotopes in the E. Mediterranean and the Levant

- Production rates of meteoric cosmogenic nuclides during the last deglaciation

L. GENE HENRY

Date Orals Passed: 4/12
Advisory Committee: McManus, Hemming, Anderson

Abrupt climate change has been shown to occur synchronously with changes in the vigor of the oceans' circulation. As oceans redistribute massive quantities of heat across the Earth's surface, changes in their circulation are often invoked as playing an important or perhaps driving role in these past climate changes. Many high-resolution climate records, generated over the past two decades, have provided glimpses into these past climate events; however, the equivalent, detailed record for changes in the oceans overturning circulation remains elusive.
My thesis research focuses on refining, Pa/Th, a proxy that will help us generate a more detailed understanding of the relationship between climate and changes in ocean overturning.
Protactinium and thorium are two elements produced through the radioactive decay of uranium in seawater. As the concentration of uranium is well known and relatively homogenous in the ocean, the disparate chemical properties of these two elements help us to understand the strength of the oceans' circulation regime, elucidating the role of the oceans in global climate change.

Abrupt shifts in the Atlantic's circulation regime have been inferred from carbon isotopes within benthic foraminfera, geostrophic gradient shifts captured in oxygen isotope data from benthic foraminifera, and the change in burial rate of 231Pa/230Th in bulk sediment. Drift deposits are often selected for 231Pa/230Th paleoceanographic reconstructions because the sedimentation rates far exceed those of the mean ocean average, thus allowing for resolution of transient climate events not preserved in other seafloor sediment cores. The fine sediment (<20um) that makes up the majority by mass of these deposits is chiefly carried from non-proximal localities. Previous work suggests that the fine fraction of the sediment carries a disporportionatly high

concentration of authigenic thorium, 230Th , and extra-terrestrial helium, 3He, two nuclides frequently employed as constant-flux proxies in the aid of climate reconstructions from sediments.

MICHAEL HOWE
Date Orals Passed: 4/14
Advisory Committee: Ekström, Nettles, Webb

My research focuses on surface wave observations. Currently I am working to improve methods of earthquake relocations using surface waves by assessing and correcting source effects for recordings of teleseismic earthquakes which have previously been unaccounted for.

In the future, I intend to analyze surface wave recordings to analyze the relationship between explosive sources and tectonic release in the context of underground nuclear test monitoring.

ALLISON W. JACOBEL
Date Orals Passed: 10/14
Advisory Committee: McManus, Anderson and Winckler

The position of the Intertropical Convergence Zone (ITCZ) is hypothesized to play an important role in tropical circulation, in linking the climate of the northern and southern hemispheres and in predicating important changes in ocean overturning, particularly on deglacial timescales. My dissertation will present reconstructions of the paleo-position of the ITCZ through the quantification of $^{230}Th_{xs,0}$-normalized ^{232}Th fluxes in marine sediments which serve as a proxy for dust flux. Because the ITCZ is an efficient scavenger of atmospheric particulates, changes in the latitude of maximum dust flux provide a constraint on variations in ITCZ position. Specifically, my current research focuses on reconstructing high-resolution (sub-millennial) records of dust flux from 0-350 ka BP at several sites in the central equatorial Pacific (Cruise ML1208).

HELEN JANISZEWSKI
Date Orals Passed: 5/15
Advisory Committee: Gaherty, Spiegelman and Abers

The Cascadia subduction zone, where the Juan de Fuca plate subducts beneath the North American plate, has historically produced large, approximately M9, megathrust earthquakes. Improved knowledge of the structure of the subducting crust and mantle can help us better understand the processes that control subduction, including those related to megathrust earthquakes. We use three seismic datasets to image different properties of the region at different scales. (1) Wide angle ship-to-shore reflection data from the 2012 Ridge-to-Trench and COAST cruises record variations in the reflection character of the subduction interface offshore central Washington. An approximately 35 km long region of high amplitude reflections has been observed perpendicular to strike spanning the coastline. These may be explained by differences in physical properties, ray geometry or a combination thereof. (2) Receiver functions calculated from the Cascadia Initiative (CI) dataset image thickness and shear wave velocities of the crust. Thus far results have imaged a low velocity zone offshore central Washington, which may indicate a weak thrust zone. (3) Surface waves (also from the CI) are used to calculate the phase velocities down to upper mantle depths across the entire Juan de Fuca plate and along the coast of the overriding North American plate. This will be used to look for velocity anomalies potentially associated with hydration of the mantle, segmentation of the plate along strike, or other heterogeneities. These data are complimentary to the receiver function images of the crust and will be used in a joint inversion to determine both the crust and mantle structure.

In addition, many of these data are from instruments deployed in an offshore environment. In particular, receiver functions have been challenging to calculate at ocean bottom seismometers (OBS) in the past due to interference from the water column. Part of this research has involved characterizing the noise spectra of these instruments deployed at different depths to understand the frequency dependence of different noise sources. Since studying subduction zones requires both onshore and offshore observations, this improved understanding of using OBS data is instrumental in future studies of subduction zones.

HYEWON KIM

Date Orals Passed: 5/15
Advisory Committee: Ducklow, Martinson, Goes

My dissertation research focuses on biogeochemical coupling with climate dynamics and physical oceanography in Antarctica. The West Antarctic Peninsula (WAP) has experienced the most rapid response to climate change than any other place on the planet; teleconnections with climate variability such as ENSO and the Southern Annular Mode (SAM) are well reported. Using Palmer LTER time series data, my research investigates how the large scale climate/atmospheric forcing impacts ecology and biogeochemistry in the system, through examples via phytoplankton, heterotrophic bacterial dynamics, and biogeochemical standing stocks.

Based on interdecadal observational data and statistical models, I have addressed intraseasonal to interannual covariability of phytoplankton, bacteria, and biogeochemical standing stocks; I established physical and climate forcing mechanisms predicting the variability, which includes interactions between SAM and ENSO, sea ice dynamics, and water column stability parameters. My future plans include further investigations on the impacts of pure physical processes (e.g. mixing) on the observed variability in the biogeochemistry. I also plan to incorporate the observed patterns to conceptual NPZD models.

JIYAO LI
Date Orals Passed: 5/13
Advisory Committee: Shillington, Webb, Savage

Current seismic behavior and variation of seismic reflectivity signature for megathrust in the Alaska/Aleutian Subduction zone

Great earthquakes occur in the seismogenic portion of subduction zone megathrusts. Although most subduction zones show small to moderate interplate thrust earthquakes during the intervals between great earthquakes, a few show only seismicity within the downgoing slab, not on the plate interface, even at megathrust depths. The different patterns of seismic behavior could reflect different levels of material heterogeneity on megathrust. Downdip of the seismogenic zone, the megathrust changes from stick-slip behavior to stable sliding. Competing models suggest that the transition is controlled by temperature or the intersection of the megathrust with the serpentinized forearc mantle wedge. In some subduction zones, changes in behavior appear to be accompanied by changes in seismic reflection signature.

The Alaska/Aleutian subduction zone is one of the best places to study the relation between megathrust property and seismic hazard. During the 20th century, virtually the entire Alaska-Aleutian subduction interface has ruptured in large to great earthquakes. The 1964 Mw 9.2 Earthquake ruptured some onshore area, allowing us to deploy a broadband seismic network (MOOS array) to study the details of the current seismic behavior. Further west, the rupture zone of 1938 Mw 8.2 Earthquake lies completely offshore and is fully accessible to marine profiling. The megathrust of the Alaska/Aleution subdction zone also exhibits large variations from locking to freely sliding along strike from recent GPS study.

My thesis focuses on the seismic behavior and reflectivity of the megathrust in the Alaska/Aleutian subduction zone and consists of:

1. A detailed study of seismicity recorded by the MOOS array. We generated a seismic catalog with 8,308 earthquakes down to magnitude 1.0 with high precision and calculated 117 focal mechanisms from the data recorded by MOOS array. Most microearthquakes are showing normal faulting mechanisms, and the direction of the T axes generally follows the dipping direction of the slab, indicating that they lie inside the subducting slab under down-dip extension or result from plate bending. Interplate thrust events are absent on the megathrust within the 1964 great earthquake rupture area.

2. Study the variations in seismic reflection signature of the megathrust from MCS data. We trace the reflections of the plate interface from the trench to place 140km landward on the dip profile across the rupture zone of the 1938 Mw 8.2 earthquake. Large variations in the reflection response are observed with depth. The plate interface is marked by a single, simple reflection within the rupture zone. Farther landward, 120 km from the trench, the megathrust reflection

changes to a brighter and wider (~12 s twtt) zone of reflectivity, where more abundant intraslab seismicity as well as episodic tremor and slip occur. The change in the megathrust reflection response appears to occur where it intersects a shallower band of reflectivity, which we tentatively interpret as the continental Moho.

XIAOQIONG SAGE LI
Date Orals Passed: 3/16
Advisory Committee: Ting, Kushnir, Biasutti

Asian summer monsoon changes in response to greenhouse gases and anthropogenic aerosols

The Asian monsoon is one of the major monsoon systems in the world with critical climate impacts. Current global climate models show large uncertainties in simulating past and future monsoon changes. Understanding the physical processes contributing to the monsoon responses due to human-induced climate change is essential for reducing the uncertainties of hydroclimate projections.

In my research, I use observational data, outputs from state-of-the-art coupled climate models, as well as idealized atmospheric general circulation model (AGCM) experiments to examine the effects of human-induced changes on the monsoon system and the underlying physical mechanisms. I use statistical techniques and idealized modeling to separate the relative roles of natural climate variability and anthropogenic climate change for the 20th and 21st century. For externally forced monsoon changes, I focus on the roles of greenhouse gases (GHGs) and anthropogenic aerosols to identify the relative contributions of moisture (thermodynamics) and atmospheric circulation (dynamics). Furthermore, I perform AGCM experiments with prescribed sea surface temperatures (SSTs) to analyze the monsoon rainfall and circulation responses to GHGs or aerosols on different time scales: the fast adjustment without the mediation of SSTs and the slow response due to SST feedbacks. The ultimate goal is to gain a thorough understanding of the multiple physical pathways by which GHGs or aerosols impact the Asian monsoon, to improve predictive capability of future monsoon changes.

NORA MASCIOLI
Date Orals Passed 4/15
Advisory Committee: Previdi, Fiore, Ting

Impacts of anthropogenic aerosols on U.S. climate: extreme events, stagnation, and the warming hole

Anthropogenic aerosols remain one of the largest sources of uncertainty in our understanding of and ability to project present and future climate. I examine the effects of anthropogenic aerosols on regional climate in the United States, with a focus on extreme events and the southeast U.S. “warming hole”. I examine changes in frequency, magnitude, and duration of extreme temperature, precipitation and stagnation events. Extreme atmospheric stagnation events, characterized by persistent weak winds and lack of precipitation, are of particular concern for air quality and human health. The lack of ventilation and scavenging by precipitation allows pollutants to build up to dangerous levels in the boundary layer. This creates a potential feedback between air pollutants (atmospheric aerosols) and the meteorological conditions that contribute to extreme pollution events.

Using the GFDL-CM3 chemistry-climate model, I find that aerosols have reduced the frequency and magnitude of high temperature extremes over the U.S. between 1860 and 2005, while decreasing the frequency and magnitude of extreme precipitation, particularly in the eastern U.S. As a result, aerosols have largely cancelled out the effects of greenhouse gases over the historical period. However, emissions of anthropogenic aerosols are projected to decrease in the future, unmasking the impacts of greenhouse gases during the next few decades.

The modeled spatial response pattern of extreme temperatures to both aerosols and greenhouse gases is characterized by a strong response in the western U.S., moderate responses in the central and northeast U.S., and a weak or absent response in the southeast U.S., collocated with the observed “warming hole”, one of the few regions across the globe which has not warmed

significantly over the twentieth century. I find that the weak temperature response in this region is tied to changes in the moisture budget, driven by changes in regional circulation patterns and the westward extent of the Bermuda High.

I will use results from multiple global climate models to evaluate how the frequency, intensity, duration, and spatial extent of U.S. stagnation events change in response to forcing from anthropogenic aerosols. I will use observations of U.S. air stagnation from NCDC in conjunction with GFDL-CM3 to examine specific large-scale stagnation events (such as summer 2012) and identify key atmospheric drivers (such as changes in the Bermuda High). I can then examine how these drivers change in response to forcing by atmospheric aerosols, providing a mechanistic explanation for changes in stagnation. Finally, I will use a series of sensitivity simulations performed by several chemistry-climate models to examine the impacts of aerosols from different source regions and from individual aerosol chemical components on U.S. stagnation events.

Ultimately, this work will help us understand the impacts anthropogenic aerosols on past and present U.S. climate, which will in turn improve our ability to project the effects of their removal over the next few decades.

DARREN McKEE
Date Orals Passed: 4/15
Advisory Committee: Martinson, Gordon, Yuan

The west Antarctic Peninsula (WAP) is bordered by the Antarctic circumpolar current (ACC), which flows adjacent to the continental shelf. Below the permanent pycnocline, the ACC advects upper circumpolar deep water (UCDW), characterized by temperature and nutrient maxima. Understanding the transport of UCDW onto the WAP shelf is important for two main reasons. Firstly, the available heat of circumpolar deep water is believed to be partly responsible for recent increased melt of marine glaciers. Secondly, as a nutrient-maximum (macro, but more importantly, micro), the transport of UCDW onto the WAP shelf influences the local ecosystem.

One of the primary goals of my research is to understand the processes of shelf-slope exchange along the WAP margins. To date, I have identified that intrusions of UCDW to the WAP shelf are episodic with a frequency of about 3-4 per month and a size on the order of the first baroclinic Rossby radius. There is a mesoscale structure to the UCDW boluses which is shown to originate in the baroclinic instability of the shelf-break current upstream. The advective component of the intruding current is coherent with the along-slope wind stress in the weather-band and intrusion sites are tied to bathymetry at the shelf break (both cross-cutting canyons and seaward-veering isobaths). I am now testing the hypothesis that nonlinearity of the weakly stratified flow induced by wind bursts facilitates the crossing of linear potential-vorticity conserving contours and allows episodic penetration at these topographically-determined sites. The hope is to isolate essential dynamics so as to extend these findings to regions of similar shelf-break and current configuration around the Antarctic continent. Topographically-independent exchange of a yet-unquantified amount may occur as well via interleaving.

A parallel goal of my research is to quantify the modification (by vertical and lateral mixing) of the intruding water mass. Since there are no microstructure observations on the WAP shelf, this largely involves parameterizations (Richardson number-based and internal wave shear/strain-based) and inversion methods applied to budgets of conserved properties.

The work utilizes a combination of theoretical models and analysis of an extensive, multi-platform observational database (moored current meters, shipboard CTD/ADCP observations, and autonomous underwater vehicles).

GARY MESKO
Date Orals passed: 4/14
Advisory Committee: Class, Shillington, Hemming

Magmatism at the southern end of the East African Rift System - origin and role during early stage rifting.

The process of continental rifting is fundamental to modern tectonic theory, yet details of the emergence and early evolution of continental rifts are still poorly known. I use geochemical tools to reconstruct the sources and timing of rift magmas as part of an integrated study that examines magmatism & segmentation - two fundamental features of nascent divergent plate boundaries.

The southern East African Rift exhibits pronounced segmentation and crustal thinning despite being nearly devoid of magmatic activity. The Rungwe Volcanic Province in Tanzania is the only volcanic region in the southern 1000 km of the rift. Physical models require magmatism at the onset of continental extension, but Rungwe is too small volume and located in the wrong place to serve this purpose. A detailed investigation of the timing and chemistry of Rungwe eruptions could shed light on the role of these volcanoes in initiating and sustaining regional extension. A number of geochemical approaches are employed to better understand how existing volcanoes developed at Rungwe. Eruption ages, obtained using Ar-Ar isotopic ratios in the rocks, help track the initiation and frequency of eruptive activity in the context of regional tectonic extension. Isotopic fingerprints of these lavas give context of how the mantle source here relates to sources around the globe. Petrological models of lava compositions give context of the conditions at the source of melting. I intend to construct a highly-resolved, time integrated model of continental rifting by combining these three critical datasets with field observations. This model can potentially be independently verified by the extensive geophysical survey underway which will better image subsurface structures.

KEREN MEZUMAN
Date Orals Passed: 4/15
Advisory Committee: Bauer, Fiore, Schmidt

Fire and air quality modeling within the NASA GISS ModelE global climate model
Fires directly affect the composition of the atmosphere by emitting a suite of reactive gases and particles, and are driven by natural and anthropogenic factors. I'm seeking to understand the drivers, feedbacks, and interactions of fires in the Earth system. My research aims to improve the basic understanding of the impact of biomass burning (BB) events on climate, air quality, and human health with a special focus on attributing fires to natural or anthropogenic sources.

M. RAJIB HASSAN MOZUMDER
Date Orals Passed: 4/15
Advisory Committee: van Geen, Bostick, Schlosser

"Access to safe water is a fundamental human need and therefore a basic human right" –Kofi Annan, the UN Secretary General rightly pointed out our rights to water and sanitation. Fulfillment of such a basic need is a challenge in many parts of the world because of either limited water supply or contamination of the available water. My research tries to answer questions about the fate and transport of arsenic (As), a metalloid naturally present in groundwater around the world that threatens the lives of tens of millions of people drinking untreated well water, particularly in South and Southeast Asia.

My study assesses long-term temporal variability of shallow (<30 m) groundwater arsenic concentrations across a 25-km^2 area of Araihazar, Bangladesh, where a team of health and earth scientists have been conducting research since 2000. Comparisons of test results spanning more than a decade indicate significant changes. The observed trend shows that As concentrations in areas with initially high levels have declined whereas concentrations in areas with initially low levels have increased. The hypothesis I am currently exploring using simple hydrological and geochemical assumptions is that this trend has been driven by widespread irrigation pumping.

ANGEL MUNOZ
Date Orals Passed: 3/14
Advisory Committee: Goddard, Kushnir, Baethgen

Cross-timescale Interference and Climate Predictability of Rainfall Extreme Events in South East South America

My research focuses on the physical mechanisms and potential predictability associated with climate extreme rainfall events in South East South America (SESA), at multiple temporal scales

(sub-seasonal to seasonal). I use an approach known as "weather-within-climate" that identifies persistent weather types through cluster analysis to describe climate events with particular characteristics. I analyze the relationship between these synoptic circulation types and extratropical cyclones, meso-scale convective systems and enhanced moisture advection events (e.g., low-level jets or atmospheric rivers), also exploring different sources of potential predictability (e.g., El Niño-Southern Oscillations, Southern Annular Mode, Atlantic Meridional Mode, Southern Atlantic Dipole, Madden-Jullian Oscillations and the South Atlantic Convergence Zone behavior) for these events at different temporal scales. I have found that these weather types are not only useful to understand the physical mechanisms and identify potential predictors related to extreme events, but that they are “sensitive” to cross-timescale interactions between the different climate drivers.

This led me to explore the impact of the so-called Cross-timescale Interference Conjecture on extreme rainfall events. My analysis indicates that considering cross-timescale interactions increases extreme events’ seasonal predictability in approximately 50%-70% with respect to the more traditional approach. Using these ideas I was able to design and evaluate a new methodology that is able to produce "subseasonal-to-seasonal extreme rainfall scenarios”, providing not only skillful climate information about how many extreme events to expect in SESA for the next season, but also about how, when and where are they expected to occur. Special attention is paid to the potential for the development of useful and reliable products for decision-making in different sectors in SESA.

ASMI NAPITU
Date Orals Passed: 11/12
Advisory Committee: Gordon, Yuan, Zappa

Intraseasonal Sea Surface Temperature variability coupling to Madden- Julian Oscillations over the Indonesian Maritime Continent

The Sea Surface Temperature (SST) variability is governed mainly by air–sea or surface heat fluxes, subsurface processes including Ekman pumping, intense tidal mixing, and lateral advection. All oceanic and atmospheric forcing determines the variability of SST. The Indonesian sea surface temperature are influenced by many oceanic and atmospheric forcing across different timescales, which consist of tides, Indo-Australian monsoon, El Niño-Southern Oscillation (ENSO) and Indian Ocean Dipole (IOD), and the Indonesian Throughflow. They are located at the pathway of prominent tropical atmosphere phenomena such as the Madden-Julian Oscillation (MJO), which is identified as convective and subsidence cells along the equator that propagate eastward from the Indian to Pacific Ocean.

The seasonal forcing is the largest contributor to SST variability in the Indonesian Seas, and the combined seasonal and semi-annual variability can only explain ~70% of total SST variances in Indonesian Seas. The remaining ~30% of the SST variability has not been studied, and we suspect that it is attributed to intraseasonal and interannual variation

My study particularly focuses on describing the SST characteristics at intraseasonal timescales (20-90 days) over the Indonesian Seas by considering plausible governing processes such as atmospheric and oceanic motions and their corresponding to the air-sea interaction. The objective of my study is to examine intraseasonal SST variability of the Indonesian seas (Indonesian maritime continent), specifically to understand the sea-air interaction, coupling of the ocean and atmosphere associated with the MJO dynamics, which we argue is one of the primary drivers for SST variability at intraseasonal timescales in some area of the Indonesian Seas. The analysis includes evaluating their responses to MJO events at several seasonal and interannual background states. This study is very useful for a better weather prediction in the region.

ANGELICA PATTERSON
Date Orals Passed: 9/14
Advisory Committee: Griffin, Boelman, Callahan

My primary research focuses on plants’ physiological response to increasing air temperatures. Most of my work is conducted in the Hudson Highlands Region of New York State, where proximate causes of climate change, such as insect outbreaks, severe droughts, environmental

disturbances such as forest clearings, and intense deer browsing have resulted in the mortality of dominant tree species (oaks), impacting long-term biomass, carbon dynamics, and carbon storage capacity in northeastern forests. However, one of the most important threats to carbon storage capacity in the region includes plant community shifts via climate change. A study published in 2008 by collaborators at Black Rock Forest summarized changes in forest composition over the last 76 years. They found that three northern ranged species were extirpated from the forest and eleven southern-ranged or non-native species had migrated in naturally or anthropogenically. I aim to compare a suite of physiological (photosynthesis and respiration) and leaf traits across a broad range of tree species with different historic distribution ranges (northern, central, and southern) that co-occur in this region's forests in order to understand the physiological mechanisms that may be driving species replacement as trees migrate to climatically suitable habitat. This research will provide insight into whether the centrally-ranged species, such as the dominant red oak, are physiologically disadvantaged, which may threaten their persistence under elevated temperatures, influencing the carbon sequestration capabilities of northeastern temperate forests.

CATHERINE POMPOSI
Date Orals Passed: 4/14
Advisory Committee: Kushnir, Giannini, Sobel

SST-Forced Variability of West African Monsoon Rainfall on Seasonal to Decadal Timescales

The West African Monsoon is one of the major monsoon systems on the planet, delivering the totality of rainfall to the Sahel region of Africa during a few summer months. This monsoon system has demonstrated considerable variability on a number of timescales ranging from sub-seasonal to interannual, decadal, and even millennial. Indeed, both the spatial extent and magnitude of the observed rainfall shift during the 20th Century in this region was unseen anywhere else in the world.

Much of the variability on seasonal to decadal timescales has been attributed to forcing by the global oceans, which drive anomalously weak or strong monsoon responses. However, the physical mechanisms which link sea surface temperature (SST) anomalies across the various basins to precipitation changes over land are not fully understood, nor is the interplay between competing anomalies and their resulting effects. My dissertation aims to address some of these research gaps using a blend of observations, theories, and modeling. Some of the ways in which I have been re-examining the role of the global oceans on Sahel rainfall variability are in using a moisture budget framework and idealized SST experiments to identify the atmospheric signatures that are consistent with precipitation change. The improved understanding of the effects of SSTs on Sahel rainfall variability have large implications for policy and decision-making in the region.

HANNAH RABINOWITZ
Date Orals Passed: 4/15
Advisory committee: Savage, Holtzman, Scholz

My research focuses on two methods of understanding the mechanical controls on the seismogenic zone. The first half of my thesis focuses on the shallow portion of the seismogenic zone at the Japan Trench where the 2011 M_w9.1 Tohoku-Oki earthquake slipped to the surface and caused a large tsunami, leading to the disaster at the Fukushima nuclear power plant. A year after the earthquake, an ocean drilling expedition sampled the fault zone that slipped during the Tohoku-Oki earthquake. I have used trace element geochemistry to develop a detailed stratigraphy of the plate boundary fault zone, which gives insight into the distribution of deformation in this region. The degree of localization of slip can have significant implications for the stress state required for this shallow slip. I am also developing a biomarker thermal maturity indicator (using alkenones and *n*-alkanes) to determine whether faults in the décollement region have experienced a significant temperature rise (inferred to be the result of frictional heating). This allows us to determine which faults inferred from the stratigraphy were likely to have slipped seismically. Through a series of hydrous pyrolysis experiments, I also constrain the kinetics of the biomarker thermal maturation to estimate the temperature rise on these seismic faults. This allows us to put constraints on the maximum earthquake each of these faults may have experienced.

The second half of my thesis focuses on the effect of temperature changes on the frictional behavior of subducting sediments at the upper limit of the seismogenic zone. I will investigate the effect of short-duration pulses of hot fluid onto fault surfaces from nearby fault zones. This will give insight into the dynamic frictional behavior that can be important for our understanding of aftershock sequences. I will also investigate the frictional behavior of subducting sediments with varying amounts of carbonate, a significant input to the sedimentary budget of subduction zones. Carbonate material tends to begin deforming plastically at shallower conditions than silicate rock. However, carbonate-rich sediment has been observed to demonstrate unstable slip behavior over a wider range of conditions than more clay-rich sediment. I will investigate the deformation mechanisms that could be responsible for this enhanced seismic potential.

NANDINI RAMESH
Date Orals Passed: 4/14
Advisory Committee: Cane, Seager, Abernathey

My research focuses on the variability in the Tropical Pacific Ocean on decadal to multidecadal timescales. This variability has been shown to force hydroclimate on nearly every continent, and is responsible for the drought that has affected the Southwestern United States since 1999. Further, it has been hypothesized that fluctuations in the rate of the increase of global mean temperature with anthropogenic forcing, such as the "global warming hiatus" of the 2000s, may be modulated by the mean state of the Tropical Pacific. My project investigates both the predictability of this phenomenon and the global ocean's response to it in terms of heat uptake. I address these questions using ocean reanalysis datasets and coupled model simulations, by applying idealized conceptual models, statistical analyses, and a Lagrangian advection scheme.

COLIN RAYMOND
Date Orals Passed: 4/14
Advisory Committee: Horton, Ting, Smerdon

Regional climate modeling, with a focus on better understanding the interaction between sea breezes and the urban-heat-island circulation during heat waves in urban areas, and how these interactions might change in the future. I am particularly interested in how these small-scale flows influence temperature and humidity conditions on subdaily timescales and ~neighborhood spatial scales. I focus primarily on the US Northeast, to utilize the rich datasets available in this region as well as to build on previous research, but aim to make my work applicable to the many urban coastal areas throughout the world.

JING SUN
Date Orals Passed: 3/12
Advisory Committee: Bostick, Chillrud, Schlosser

Developing Improved Strategies of Remediating Arsenic Contaminated Aquifers.

Arsenic is a widespread contaminant in groundwater around the world, and is highly detrimental to humans and many other organisms. Arsenic is also the second most common contaminant of concern at U.S. EPA National Priority List. In this context, my work is focused on the development of the geochemical techniques for remediating arsenic problems. The fate of arsenic contamination is often linked to iron. But their interaction is not simple in that it involves a complex network of biological and chemical (abiotic) redox processes, solid-solution phase equilibria, and both thermodynamic and kinetic controls. Therefore, I want to investigate laboratory microcosms using arsenic-bearing aquifer sediments and groundwater and also conduct field scale research, to understand the efficacy of different amendments at retarding arsenic mobility, and elucidate changes in solid-phase iron and arsenic speciation. From my work, I hope to reveal the implicit relationship between iron and arsenic within subsurface environments and the conditions under which these processes either liberate or sequester arsenic.

TAKAYA UCHIDA
Date Orals Passed: 4/17
Advisory Committee: Abernathey, Thurnherr, Goes

Seasonality of eddy fluxes due to submesoscale turbulence and reconstruction of the interior dynamics using sea-surface information

Recent development in modeling studies has shown that the vertical velocities attributable to submesoscale turbulence are crucial for the nutrient supply to the euphotic zone and hence, primary production (Levy et al., 2001). However, the frequency of the vertical velocities is comparable to the growth rates of phytoplankton and it is yet to be shown decisively whether nutrients and/or phytoplankton stay within the euphotic zone long enough for efficient nutrient utilization. At which spatial scales the submesoscale advection contributes to the nutrient supply is also unclear. We shall conduct a cross spectral analysis of velocity and tracers over the frequency and wavenumber domain to entangle the relation of temporal and spatial scales.

Another topic of interest is the modal decomposition of the interior dynamics using sea-surface information. This is motivated by the fact that through satellite observations we can only observe the sea-surface. Many methods of decomposition have been proposed by linearly superposing interior quasi-geostrophic (QG) and surface QG (SQG) dynamics (e.g. Lapeyre and Klein, 2006; Wang et al., 2013). However, these hybrid modes do not diagonalize the energy as the surface and interior modes are not orthogonal. Moreover, because the surface modes depend on wavenumber while the interior modes do not, the energetic overlap increases with increasing horizontal scale. We shall, therefore, follow the method proposed by Smith and Vanneste (2013) where they simultaneously diagonalize the energy and a generalized form of potential enstrophy along with incorporating a new view proposed by Joseph Lacasce at the SWOT meeting in Toulouse, France 2017.

Our study will focus on the Arabian Sea, which sustains the World's thickest oxygen minimum zones (OMZ). OMZs are caused by a combination of strong organic matter decomposition and poor ventilation of oxygen. In suboxic conditions, remineralization of organic matter proceed via using nitrate as an alternate oxidant, a process known as denitrification. Denitrification not only depletes the oceanic inventory of bioavailable nitrogen but also releases N_2O, a greenhouse gas. Ekman pumping due to the heavy influence by the reversal of the monsoon winds on seasonal timescale and eddy vertical velocities energized by coastal upwelling processes result in high productivity. In conjunction with the sluggish circulation, the OMZ in the Arabian Sea (abOMZ) is responsible for up to 40% of global pelagic denitrification despite occupying less than 2% of the World Ocean area. It is, therefore, crucial to understand the mechanism and future trends of the abOMZ from a climate perspective (Lachkar et al., 2016).

STEPHEN VEITCH
Date Orals Passed: 3/12
Advisory Committee: Nettles, Ekström, Gaherty

Glacial Earthquakes and Glacier Seismicity in Greenland

I am interested in a range of seismic phenomena associated with large marine-terminating glaciers in Greenland. On the global scale, I consider glacial earthquakes that produce globally observable surface waves which can be analyzed in order to provide information on the geometry and dynamics of their source glaciers. As these events may be analyzed in near-real time, they potentially represent an important means of monitoring large glaciers in Greenland for changes in their dynamic behaviour. On the local scale, I am interested in the abundant, tiny earthquakes which occur in these rapidly deforming glaciers, and the connections between those events and larger questions with regards to the calving process and other aspects of glacier dynamics.

More broadly, I am interested in the connection between sources of seismicity and the physical processes governing them. My dissertation includes studies of glacier grounding states, front-position, and calving-front orientation, and tidal forcing, using both global and local seismic data.

ABAGAEL WEST
Date Orals Passed: 3/14

Advisory Committee: Flynn, Meng, Christie-Blick

South America's relative geographic isolation for much of the Cenozoic, and the continent's reach from high latitudes to the subtropics bred a diverse, abundant, and disparate array of endemic mammals. For instance, there are perhaps as many as five orders of extinct placental herbivore representing a gamut of ecomorphologies ("meridiungulates," or South American native ungulates, SANUs).
Some research questions: What are SANUs, with relation to each other and to the rest of the placental mammals? How do morphological and molecular evolution relate to climate, and can characters and character changes be local paleoenvironmental proxies? Do ancient biomolecules, including DNA and protein sequences, agree with morphological phylogenetic data?

Some projects: I am expanding the Assembling the Tree of Life project Mammalia dataset, adding taxa to test the hypothesis that some of the SANUs are related to African mammals while others are related to Holarctic ungulates. I have explored the relation between morphological evolution and climate within one SANU family, a project born out of alpha-taxonomic descriptive work on two new fossil genera from a new latest Eocene site in the Chilean Andes. I have also looked in fairly exhaustive detail at the chronologic basis for calibrating phylogenetic comparative and other macroevolutionary studies, reviewing and revising the mammal-based biochronology of Cenozoic South America. For my most recent project I am extracting ancient DNA from various North American ungulates to test hypotheses surrounding Pleistocene population and ecosystem dynamics, as well as phylogenetic (taxonomic) hypotheses, with an eye towards testing and refining ancient DNA methods in the lab and in silico.

MICHAEL WOLOVICK

Date Orals Passed: 3/12
Advisory Committee: Buck, Bell, Creyts

Sliding Dynamics and Internal Structure of Ice Sheets

Basal sliding is an important part of ice sheet dynamics. My work is focused on basal sliding and hydrology, and the linkages between these processes and ice sheet stratigraphy.

1. Identification and Control of Subglacial Water Networks Under Dome A, Antarctica

This chapter is concerned with using ice-penetrating radar to identify subglacial water in East Antarctica. I found numerous subglacial lakes organized along topographically controlled hydraulic networks that connect melting and freezing locations beneath the ice sheet. Published in JGR-Earth Surface in 2013.

2. Traveling slippery patches produce thickness-scale folds in ice sheets

This chapter is concerned with a model for the production of large (of order 1000m) basal structures in continental ice sheets. Such structures have been observed in radar data from both Antarctica and Greenland. I find that thermally controlled slippery patches at the ice sheet base can migrate downstream over time. Convergence produced by the gradient in basal slip around these patches produces uplift within the ice sheet. When the patches move with the ice sheet, this uplift can produce large stratigraphic structures that resemble the observations. This new feedback stresses the importance of time-variable basal slip and enlarges our understanding of the relationship between slip and stratigraphy. Published in GRL in 2014.

3. Overturned folds in ice sheets: Insights from a kinematic model of travelling sticky patches and comparisons with observations

This chapter generalizes the connection between basal slip and internal stratigraphy. Here I used a kinematic model in a moving reference frame to identify overturning vortices that form in the lower portion of the ice column above a moving sticky patch. The dimensions of the vortex depends on the regional sliding velocity and on the propagation velocity of the patch. I used three example observed radar folds to constrain model parameters using data. Submitted to JGR-Earth Surface in August 2015.

4. Basal freeze-on: Mechanisms and volumes

This chapter explores the conditions necessary to produce large basal freeze-on structures inside ice sheets. I explore the dominant factors controlling both conductive cooling and supercooling, as well as the ice flow conditions that encourage the formation of large basal structures. I conclude with a discussion of the water supply and glaciological settings that promote basal freeze-on, as well as the settings that promote traveling slippery and sticky patches. In preparation.

YINGZHE WU

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Advisory Committee: Goldstein, Pena, B. Anderson

Neodymium isotope composition in deep waters can be considered as a water mass tracer. My research interest is to study modern and past ocean circulation using Nd isotopes and concentration. It consists of the following components:

1. The high Nd isotope ratios of North Pacific Deep Water (NPDW, εNd = ~ -4) have been difficult to reconcile with the inputs as reflected in surface waters (e.g. Jones et al. EPSL 2008). An additional volcanic component has been suggested. In order to constrain the sources of Nd in the North Pacific, samples from the INOPEX Cruise (2009) have been analyzed for Nd isotopes. Below 2500m in samples from the Aleutians-Kamchatka and East Asia margins, the εNd values are convergent at ~ -3.6, consistent with NPDW. However, samples above 2500m from Aleutians-Kamchatka show higher εNd than corresponding depths near East Asia, consistent with higher volcanic contributions near the Aleutians-Kamchatka. In the shallowest 500m the εNd trends to more positive values toward the surface (to -1.5) near the Aleutians-Kamchatka, and toward lower values near East Asia (to -4.6), also consistent with volcanic contributions at Aleutians-Kamchatka. The highest εNd at Aleutians-Kamchatka coincides with a previously reported Fe concentration maximum, interpreted as Fe mobilization from reduced marginal sediments (Lam and Bishop GRL 2008), which may also be a means of mobilizing REE.

2. Over the past several years, studies have increasingly focused on the potential of external addition of Nd along water mass transport paths (for example through “boundary exchange” with particulates or addition from groundwaters), thus challenging the idea that Nd isotopes behave “quasi-conservatively” in the oceans. The SW Atlantic, with the major water masses involved in the AMOC (southward flowing NADW, northward flowing AAIW and AABW), is arguably the best place on Earth to evaluate how well Nd isotopes trace water mass mixing, in order to clarify its value for following the AMOC through time.
We will report Nd isotope ratios of seawater collected on the SW Atlantic meridional transect of the NIOZ West Atlantic GEOTRACES Cruise Leg 3 (RRS James Cook 057), which sampled seawater profiles and the sediment surface at 18 stations between 0-50°S. Most stations are sampled in the open ocean, providing a test of whether Nd isotopes show quasi-conservative mixing systematics away from continental margins. The cruise section also provides several opportunities to test the potential effects of external Nd input.

3. The modern Southern Ocean has significant input from NADW, which is reflected in Nd isotope compositions of the Southern Ocean, and when the Atlantic meridional ocean circulation weakens, so will the North Atlantic signal. Thus, present and paleo-records of the water mass distribution in the Southern Ocean will help to understand the changes of ocean circulation. Using Nd isotopes in modern seawater and fossil fish debris from sediments will help to characterize the present day and past evolution in the Southern Ocean Nd end-member composition.

ANASTASIA YANCHILINA

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The Late Pleistocene Evolution of the Black Sea

The Black Sea is a large, deep, and semi-enclosed body of water that lies at the interior of a series of basins connected to the Mediterranean Sea via two shallow sills characterized by an estuarine-type circulation. This hydrologic setting changed in the past. Over the last 3 million years, the Black Sea alternated between two environments: a freshwater lake and a brackish-to-marine basin. The factor that controlled the preferential state is the form of the connection with

the Mediterranean Sea. The entry of salt water is limited by the height of the global sea level relative to the threshold depth of the sill in the Bosphorus portal. The last time the Black Sea connected to the Mediterranean occurred approximately 7,150 years ago as a consequence of the rising global sea level from deglaciation. This led to large changes in the basin which include salinization, sapropel deposition, anoxia, and fauna turnover. This event is clearly seen in both shelf and slope cores.

Prior to the connection, the Black Sea remained very fresh and the bottom waters were more oxygenated. Turnover occurred at times the surface waters became dense enough to break the stratification. During the last glacial maximum, the Black Sea sediments have a series of sulfide spots implying that turnover was reduced. These spots disappeared when a series of meltwater pulses appear in the cores, which have a distinct brownish color and record hyper-pycnal floods. Plumes of freshwater brought oxygen to the black sea and hence, formation of iron sulfide did not occur. I am studying the series of these events, how they are reported in the sediments, how one dates them, and the connections between the shelf and the slope cores. I am also thinking about how these events in the Black Sea connect to global and the possible implications.