2018 CEOAS REU Symposium
Wednesday, August 22, 9:30-noon
Wilkinson 203

9:30 Oxygen respiration and hypoxia in the benthic boundary layer on the Oregon shelf
Devon McClane, Chemistry major, Skidmore College
CEOAS mentor: Clare Reimers

The severity of hypoxic events in waters on the Oregon shelf have been increasing since the early 2000s, affecting the coastal ecosystem and Oregon economy. A model proposed in 2014 by *Siedlecki et. al.* provides a template for predicting future oxygen demands, however it does not fully represent the shallow, more productive area of the shelf closer to shore. Using optical fibers to excite a fluorescent enzyme embedded in sensor spots fixed to the inside of sealed water bottles, water samples from ~ 30 m and 80 m within the shelf benthic boundary layer were monitored at in situ temperatures to determine the rate of oxygen consumption in the water column (in July, ~ 1 mmol d^{-1} and ~ 0.5 mmol d^{-1} respectively; in August, ~ 2 mmol d^{-1} and ~ 1 mmol d^{-1} respectively). In conjunction with rates from sediment-water interface incubations, these rates were compared to *in situ* measurements of declining dissolved oxygen recorded throughout the summer of 2018 by sensors on the Ocean Observatories Initiative (OOI) Endurance Array benthic platform to confirm the rates determined by the incubations. The sediment-water interface consumes oxygen at a faster rate than that of the water column, which does not align with the *Siedlecki et. al.* model. The difference is interpreted to be caused by the settling of more large particulate matter to the seafloor, on the shelf closer to shore.

9:45 Reconstructing temperature and carbonate ion concentration in the Santa Barbara Basin using planktic foraminifera trace element composition
Elizabeth Davidson, Geology major, California State University- Sacramento
CEOAS mentors: Jennifer Fehrenbacher and Theresa Fritz-Endres

Foraminiferal trace elements are widely applied in paleoceanographic reconstructions. Recently developed foraminiferal trace element proxies offer the opportunity to reconstruct past temperature and carbonate chemistry. Seasonal upwelling results in variable temperature and $[CO_3^{2-}]$ in the Santa Barbara Basin making this region an ideal location to examine the effect of carbonate system parameters on trace element concentrations and foraminiferal calcification. In this study, we analyze foraminifera obtained from a new Santa Barbara Basin core that spans the last 500 years, a period of time for which previous paleoceanographic reconstructions exist for validation of these newly developed proxy relationships. We use LA-ICP-MS to analyze the trace element composition of individual specimens of the regionally abundant species *Neogloboquadrina incompta*. We apply species-specific calibrations to reconstruct both temperature and the carbonate chemistry at 50-year intervals. Mg/Ca ratios and the recently updated calibration for *Neogloboquadrina incompta* were used to reconstruct temperature. B/Ca ratios of *N. incompta* were used to reconstruct $\Omega_{calcite}$. The results found an overall decrease in temperature between the 1575 and 1960 and an increase in $\Omega_{calcite}$. Results were compared to existing temperature and carbonate chemistry reconstructions and historical records from this region.

10:00 Intrashell trace element variability in the deeper dwelling planktic foraminifera Globorotalia menardii: implications for marine snow as a source of elevated trace elements
Clay Clarkson, Biology major, Texas A&M University- Corpus Christi
CEOAS mentor: Jennifer Fehrenbacher

The Quaternary period is defined by cyclic glaciation that alters global ocean chemistry and biological productivity. Fluctuating oceanographic parameters, such as changes in temperature and carbonate chemistry, are reflected in the trace element (TE) geochemistry of foraminiferal calcite, which provide an archive of oceanographic conditions through time. TE/Ca ratios are often higher and more variable in

deeper dwelling species compared to mixed-layer species and the mechanism responsible for intrashell variability are poorly understood. Here, using laser ablation ICP-MS depth profiling, we explore intrashell trace element variability in the non-spinose species *Globorotalia mendarii* of the Holocene, Deglacial, and Last Glacial Maximum time periods from the Western Equatorial Pacific. Geochemical analysis performed on the calcite of these species reveal elevated and variable Mn, Ba, Mg, and Zn to calcium ratios. We find intrashell Ba/Ca and Zn/Ca is higher in the early ontogenetic calcite and often displays co-variation and banding that is similar to the Mg/Ca banding present in the non-spinose species *Neogloboquadrina dutertrei*. Banding is absent in the crust or gametogenic calcite. This data may support the hypothesis that the source of elevated TE/Ca ratios in deep-dwelling non-spinose species is due to calcification within microhabitats of marine snow, which can have elevated TE/Ca ratios compared to seawater.

10:15 Break

10:30 Atmospheric nitrous oxide in the pre-800 ka atmosphere from ice cores from the Allan Hills, Antarctica

Marika Stock, Geology major, Oregon State University
CEOAS mentor: Ed Brook

Nitrous oxide (N_2O) is an important greenhouse gas and destroys stratospheric ozone. Current N_2O concentration records from ice cores span the past 800,000 years. In pre-industrial times, N_2O varies with climate on glacial-interglacial time scales with a concentration range of about 200 to 300 ppb. Here we report N_2O concentrations from significantly older (up to 2.7 my) discontinuous samples from shallow ice cores of the Allan Hills Blue Ice Area, Antarctica. The ice was dated by measuring the deficit of ^{40}Ar in trapped air relative to modern values (Higgins et al., 2015; Yan et al., in review). N_2O measurements on twelve samples were made using a melt-refreeze extraction method and gas chromatograph with an electron capture detector. N_2O concentrations for nine other samples were determined using dry-extracted air collected primarily for measuring $\delta^{13}C$ of CO_2. Samples were binned in age ranges corresponding to either the Mid Pleistocene Transition (MPT, ~ 800-1200 ka) or pre-MPT time. Preliminary analyses show that the range of N_2O concentrations from samples categorized as MPT is approximately 220 ppb to 290 ppb, while sample measurements from the pre-MPT category range from about 230 ppb to 310 ppb. Values similar to those of full glacial conditions during the last 800 ka (approximately 200 ppb) do not occur in the existing dataset. This feature seems compatible with the observations that pre-MPT values of δD and CO_2 never fall as low as glacial values of the past 800 kyr. Four of the samples are believed to contain excess carbon dioxide from respiratory activity near the ice/bed interface. Two of these four also have anomalously high levels of N_2O (>400 ppb), suggesting microbial production of this gas. Concentration measurements from additional available samples should provide further insight into the MPT and Pre-MPT history of N_2O.

10:45 Firn smoothing of abrupt methane variations in the South Pole ice core

Ekaterina Hood, Marine Science and Geological Sciences major, University of Miami
CEOAS mentor: Christo Buizert

Trace gas records of abrupt Dansgaard-Oeschger (D-O) climate variability in polar ice cores are smoothed due to processes in the firn layer. Molecular diffusion and gradual bubble trapping are two specific mechanisms known to contribute to a broadened gas-age distribution, although these mechanisms remain poorly understood and attempts at modeling these processes fall short. The gas-age distribution in mature ice is commonly assumed to be roughly 10% of delta-age (Δage), or the gas-age, ice-age difference. In order to better understand the firn smoothing mechanism and ultimately improve interpretation of trace gas records, we examine an 88 m-long section (1,359-1,271 m or 32.9-27.8 ka BP gas-age) of the South Pole ice core. The section of interest encompasses D-O events 3, 4, and 5, corresponding to a series of abrupt CH_4 variations suitable for understanding the complex ways firn

smoothing influences ice core records of abrupt atmospheric trace gas excursions. Using a melt-refreeze method to extract gases, a series of discrete methane measurements were obtained and processed. The South Pole data were compared to the continuous, ultra-high resolution WAIS-Divide Ice Core Methane Record, and found to be smooth relative to WAIS-Divide, although observed smoothing is less than both published model-based estimates and the 10% of Δage rule-of-thumb. By providing a well-resolved methane record and constraint on smoothing estimates, we hope to inform research that seeks to fill crucial gaps in our understanding of coupled trace gas excursion and climate dynamics over the past 40,000-50,000 years.

11:00 Break

11:15 Impacts of Holocene Antarctic Ice Sheet discharge in a coupled ocean-atmosphere model
Schmitty Smith, Geosciences and Mathematics major, Northland College
CEOAS mentor: Andreas Schmittner

Centennial global climate variability, an important factor in the next centuries' climate, may be significantly influenced by freshwater discharge from the Antarctic ice sheet. A dynamic coupled Ocean-Atmosphere model (OSUVic) is used to further explore the impacts Bakker et al. (2016) found from Antarctic ice sheet discharge on the Southern Ocean in a simpler, intermediate complexity climate model without a dynamic atmosphere. OSUVic includes a dynamic atmosphere suited to study the effects on winds and clouds and how those changes feed back onto the ocean. The OSUVic model at T21 resolution was run for two, 400-year long simulations, one with a constant freshwater discharge, one with discharge according to the Antarctic ice sheet model simulations by Golledge et al. (2014, see Bakker et al. for reference). Significant impacts are found in the Southern Ocean, with increased ocean stratification influencing the rate of Antarctic Bottom Water formation. Remote atmospheric and oceanic impacts in the tropics and North Atlantic, such as a northward shift of the Intertropical Convergence Zone and changes in the Atlantic Meridional Overturning Circulation in response to Southern Ocean warming are also investigated.

11:30 Modeling the effects of mesoscale eddies on large-scale circulation, mixing and tracer distributions in a global ocean circulation model
Nadia Cohen, Physics major, University of North Carolina at Chapel Hill
CEOAS mentor: Andreas Schmittner

Mesoscale eddies are circulating currents, ranging from length scales of 10 km to 100 km and time scales of weeks to months. They play an important role in ocean dynamics, including the transport of heat, salt and other geochemical tracers over long distances. Many global coarse-resolution ocean models use the Gent and McWilliams (1990) parameterization based on the thickness diffusivity K_{GM}, which accounts for the advective effects of turbulent lateral mixing by mesoscale eddies. Many models use constant values of K_{GM} and of the isopycnal diffusivity K_{iso} for tracers. In the present study we aim to improve the parameterization of the effects of mesoscale eddies by incorporating spatially and temporally varying thickness and isopycnal diffusivities in the University of Victoria (UVic) Earth System Model, version 2.9, as suggested by Eden and Greatbatch (2008). We vary two tunable parameters, c and γ, analyze and compare the results of the models' distributions of temperature, salinity, density, diffusivities, length scales, eddy kinetic energy, and radiocarbon with past and present observational data. We ran 15 different models with c values of 0.25, 0.50, 1.00, 2.00 and 4.00 and γ values of 100, 200 and 400. The goal of the analysis is two-fold: to understand the effect of varying c and γ values on mixing, which we can directly observe by comparing isopycnals from the model to observational data, and to discover which values of c and γ optimize the model. We found that varying γ shifts isopycnals horizontally whereas varying c changes the slope of the isopycnals. The model run that best agreed with observational data is the one with the values of 0.25 for c and 400 for γ.

11:45 Wintertime heat and salt transport in the South China Sea: comparison between Taiwan and Vietnam
Pha Truong Phan, Ocean Sciences major, Oregon State University
CEOAS mentor: Kipp Shearmann

The Kuroshio Current intrudes into the South China Sea (SCS) through the Luzon Strait during the winter due to dominated northeasterly monsoon winds. An investigation off the coast of Taiwan and Vietnam will be done to understand the heat and salt transport into the SCS from the Kuroshio Current. Little is understood about the dynamics of wintertime circulation in the SCS with the intrusion of the Kuroshio Current. Analyses done will use data from Autonomous Underwater Vehicle (AUV) glider observed off the coast of Taiwan and Vietnam. This work will provide insight into how the intrusion of the Kuroshio Current alters the circulation of the SCS in the wintertime.

12:00 Adjourn, lunch in Burt Hall West Courtyard

Additional students who presented on different dates:

The role of early-juvenile coastal Pacific Hake, *Merluccius Productus*, in the food web of the northern California Current
Charlie Donahue, Marine Biology major, Oregon State University
CEOAS Mentor: Kim Bernard

Under normal ocean conditions Pacific hake will spawn off the coast of southern California and early juveniles will feed off the coast of northern California. However, in warmer years it has been observed that Pacific hake will spawn further north, which means that early juveniles will feed off the coast of Oregon. It is possible that early-juvenile Pacific hake will compete for resources with early juveniles of other species, such as salmon and rockfish. This could negatively impact those species, which are important fisheries in the economy of the Pacific Northwest. My research will use gut content analysis and bomb calorimetry determine what early-juvenile Pacific hake are eating and what the energy value of those prey species are. I will also determine the energy content of early-juvenile Pacific hake as potential prey to higher trophic levels. Then I can use these data, along with population data (biomass and distribution from NOAA collaborators) and literature values of the energy requirements of early-juvenile Pacific hake (or similar species), to estimate the trophic impact of early-juvenile Pacific hake off the Oregon coast. My study will contribute to fisheries research being conducted both at OSU and at NOAA and will inform fisheries management in the region.

Drug trafficking and Central American protected areas: developing a proxy database of illicit activities from media reporting in Guatemala, Honduras, and other countries from 2000 to 2018
Olivia Cameron. Natural Resources major, Oregon State University
CEOAS mentor: David Wrathall

On a global scale, illicit economies have dramatic, unrecognized impacts on the environment. Cocaine has been recognized as a major driver of deforestation inside Central American protected areas (Sesnie et al. 2017). However, as illicit activities are intentionally obscured, the key problem is reliable data on these clandestine activities. Proxy data is needed to better determine if illicit cocaine trafficking in Central America spatially and temporally co-occurs with deforestation in protected areas. To resolve this problem of data scarcity and establish a relationship between deforestation and the illicit drug trade, I am collating a database of media reporting from Guatemala, Honduras, and other Central American countries (to be determined) for years 2000-2018 and performing preliminary analysis. The ultimate aim is to create a proxy indicator for the spatiotemporal intensity of cocaine trafficking that may be used to evaluate claims regarding landscape transformations. Media reports of events linked to illicit activity (based upon certain keywords) were acquired from Guatemala's

Prensa Libre and other national news outlets. Databases were compiled for each country. (In Honduras, this was approximately 500 events; in Guatemala, approximately 700.) These databases will be finalized and collated in order to develop hotspot and kernel density maps for relative and absolute intensity measures of narcotrafficking patterns over spatial and temporal scales. We expect that this proxy will provide us with necessary data to establish a clear statistical relationship between the timing and location of cocaine transit and deforestation. We expect this relationship to be most abundantly clear in protected areas. These findings on the risks that illicit economies pose to forest environments have implications for conservation governance, protected areas management, and sustainable development, not only in Latin America, but in other poor, developing countries vulnerable to illicit economies.

Constraining aeolian erosion rates using exposure age dating: implications for dust generation and surface evolution on terrestrial planets

Sara Lapinski, geology major, Oregon State University
CEAOS mentor: Shan de Silva

Aeolian processes that occur on planetary bodies such as Venus, Mars, and Titan create dramatic wind sculpted landscapes. Understanding the ability of the wind to erode landscapes and transport sediment is therefore fundamental to understanding how planetary surfaces evolve. With the many rover missions and the plans for future human habitation on Mars, the role of wind has practical implications for rover trafficability, surface operations, and human operations there. A critical gap in our understanding is the lack of quantitative data for aeolian erosion on planetary bodies. Quantification of the process on other planetary bodies requires constraints from terrestrial analogs and I propose to do this by constraining aeolian erosion rates on ignimbrites in the Campo Pierdra Pomez region of the Argentinian Puna through exposure age dating. By measuring cosmogenic Beryllium 10 the ages and the erosion rates of wind eroded surfaces can be estimated. The results will then be scaled to the Medusae Fossae Formation on Mars which is thought to be composed of ignimbrites as well. This comparison of aeolian erosion rates on Earth and Mars will lead to a better understanding of landscape evolution in our solar system.