The 5th Annual Environmental and Water Resource Engineering Showcase

Nexus of Energy, Environment, and Water

Society of Water and Environmental Graduate Students
Department of Civil and Environmental Engineering
University of California, Davis

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April 28th, 2023
Davis, California

UCDAVIS
CIVIL AND ENVIRONMENTAL ENGINEERING

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11:15 AM – 11:45 AM	**Faculty Presentation - Dr. Heather Bischel** *Exploring resource recovery insects for value proposition in organic waste management*
11:45 AM – 11:50 AM	**Break**
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12:25 PM – 12:30 PM	**Photo Session**
12:30 PM – 01:15 PM	**Lunch**
01:15 PM – 02:30 PM	**Panel Discussion** *“Navigating your career in the Nexus of Energy, Environment, and Water”* Moderator: *Holly Oldroyd* Panelists: *Rachel Kraai (Lotus Water), Bethany Robinson (Regional Water Boards), Lily Tomkovic (DWR), Liam Ekblad (Current graduate student)*
02:30 PM – 02:45 PM	**Break**
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Keynote Speaker – Dr. Edward Spang

Dr. Spang's research focuses on characterizing and optimizing the efficiency of linked food, energy, and water resource systems. This work has spanned a range of topics from examining opportunities to reduce energy use within water infrastructure systems to assessing the economic and environmental potential of cultured meat products. He has also focused much of his work on the topic of food loss and waste across the entire food supply chain, including estimating on-farm food losses, repurposing food processing byproducts, and assessing the potential for community-scale anaerobic digestion systems. To further address this interdisciplinary issue, Dr. Spang has worked to establish the Food Loss and Waste Collaborative – a collection of roughly 100 faculty, students, and staff at UC Davis, representing more than 20 different departments, research centers, and institutes on campus.

Presentation Title: Advancing solutions for linked food, energy, and water resources

Abstract: Food, energy, and water resources are critical resource flows that permeate all societal activities. These resource systems are also inextricably linked to one another. While these interconnections can complicate the management and utilization of these resources, they also enable opportunities to secure multiple benefits across resource systems through well-designed interventions. This lecture will provide an overview of research efforts in the Spang Lab that have addressed this challenge, from securing energy savings through water conservation to reducing food loss and waste across the food supply chain.

Faculty Presenter – Dr. Heather Bischel

Heather N. Bischel is an Associate Professor in the Department of Civil & Environmental Engineering at the University of California, Davis. Dr. Bischel's research characterizes environmental transport and treatment processes for trace organic contaminants and viruses in water and waste resource recovery systems. Recent projects by her group include enhancing pesticide treatment in woodchips bioreactors, harnessing enzymes in the guts of resource recovery insects to degrade organic contaminants and understanding bioaccumulation dynamics of poly- and perfluoroalkyl substances (PFAS). Dr. Bischel also leads wastewater-based disease surveillance programs for UC Davis, Healthy Davis Together, and most recently Healthy Central Valley Together (HCVT), a regional collaborative initiative that aims to increase equity in access to public health data derived from wastewater in rural and underserved communities in California.

Presentation Title:	Exploring resource recovery insects for value proposition in organic waste management
Abstract:	Combining organic waste composting with insect-bioprocessing is a promising approach to treat solid waste organics, intercept bioaccumulative contaminants, and generate valuable end-products. Our group is exploring the potential for black soldier fly larvae (BSFL) in solid-waste-resource recovery pipelines, with applications for management of landfill organic wastes, byproducts from agriculture, and sanitation systems. Insect-bioprocessing also offers a fascinating microcosm in which to study biochemical processes for contaminant degradation. Insects can be processed into marketable end products such as animal feed (from protein-rich tissues), biofuels (from fatty insect tissues), or higher-value soil amendments (enriched from insect castings). Numerous companies are already capitalizing on the capacity of insects to digest food and agricultural waste to generate value. Circular economies that recognize the value embedded in waste are critical for more sustainable solid-waste organics management.

Research Presentation – Dr. Harold Leverenz

Harold Leverenz is an environmental engineer working on the development and implementation of systems for water reuse and resource recovery from waste streams. His recent work has included the development and testing of novel water and wastewater treatment processes for nutrient recovery from urine and digestate, integrated water systems, and anoxic treatment wetlands. Harold received a B.S. in Biosystems Engineering from Michigan State University and M.S. and Ph.D. in Environmental Engineering from the University of California, Davis. Harold is a senior engineer with Biohabitats and an associate project scientist at UC Davis.

Presentation Title: Decentralized fertilizer production from urine

Panel Discussion Moderator – Dr. Holly Oldroyd

Dr. Holly Oldroyd (she/her) has held a Professorship in the Department of Civil and Environmental Engineering at the University of California, Davis since Oct. 2016, and she heads atmospheric science research at the Tahoe Environmental Research Center (TERC). She holds a Ph.D. in Civil and Environmental Engineering from École Polytechnique Fédérale de Lausanne (EPFL, Switzerland), and BS and MS Degrees in Mechanical Engineering from the University of Utah. She studies a wide range of turbulent transport in environmental flows and in particular, land-water-atmosphere interactions and carbon and water cycling in natural environments. In 2019, she was awarded the NSF-CAREER award to pursue her research in the Sierra-Nevada Mountains, and has ongoing projects in Redwood forests, the Wind River Experimental Forest (in Washington), agricultural land, and over reservoirs. She is also involved in a wide range of educational-outreach and mentoring programs, including the Society of Women Engineers, O-STEM, AvenueE, UC Davis First-Gen, and the TERC Youth Science Institute.

Invited Panelists

Rachel Kraai

Senior Planner and Project Manager, Lotus Water

Rachel specializes in the planning and integration of projects, programs, and policies to create more sustainable wastewater and stormwater management systems. Her areas of expertise include collection system planning, green stormwater infrastructure, flood resiliency, non-potable reuse, and regulatory compliance. She has worked for large and small cities and has an intimate understanding of planning and implementation challenges from the municipal point of view. She has managed multiple watershed-scale planning processes and has led development or updates of numerous guidance manuals including the San Francisco Stormwater Management Requirements and Design Guidelines and the San Francisco Graywater Design Manual for Outdoor Irrigation. Rachel is passionate about stakeholder engagement and is sought after for her ability to develop successful partnerships and innovative engagement strategies. Prior to her work in urban watershed planning, Rachel worked in sustainable transportation with a focus on bicycle and pedestrian projects and advocacy.

Dr. Lily Tomkovic

Water Resources Engineer for the California Department of Water Resources

Dr. Lily Tomkovic finished her PhD in March 2022 specializing in numerical modeling of natural systems, specifically the Yolo Bypass and the McCormack-Williamson Tract. She has worked for 2 years in consulting specializing in multidimensional models of floodplains, wetlands, and tidal marshes. She has also worked for the state for about a year balancing ecological benefits with freshwater exports from the Sacramento-San Joaquin Delta.

Dr. Bethany Robinson

Water Resource Control Engineer, Regional Water Boards

Bethany Robinson works as a Water Resource Control Engineer at the State Water Resources Control Board in the Division of Drinking Water's Regulatory Development Unit. She received her Bachelor's, Master's, and PhD in Civil and Environmental Engineering from UC Davis, where she developed an appreciation for machine learning algorithms and Thai food. She spends her free time hiking, reading, and cultivating plants.

Liam Ekblad

Current EWR Graduate Student

Liam Ekblad (they/them) is a fifth-year graduate student in Civil and Environmental Engineering at the University of California, Davis. Originally from Upstate New York, Liam holds a M.Eng. and B.S. in Environmental Engineering from Cornell University. Liam works on integrating humans in water systems models using data-driven methods. In their free time, Liam writes poetry about climate change and listens to records.

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Student Poster Titles

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Corrin Clemons	*Using Eddy-Covariance to Quantify and Partition Greenhouse Gas Fluxes at Uvas Reservoir, Morgan Hill, CA*
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Mel Johnson	*Viral Indicators & Removal Efficiency for Water Reuse*
Noah Z. Krasner	*Impacts of photovoltaic solar energy on soil carbon: A global systematic review and framework*

Ruth Thirkill	*Synoptic Hydroacoustic Assessment of CH_4 Pathways in Reservoirs and Associated Seasonality*
Samantha Sharp	*Remote sensing as a management tool for cyanobacteria blooms in inland waters: from multispectral to hyperspectral*
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Zoe Kanavas	*Predicting dissolution in geologic porous media*

List of participants

Title: Advancing health equity in wastewater-based epidemiology using wastewater surveillance data from Davis, California

Author: Amita Muralidharan (amurali@ucdavis.edu)

Advisor: Heather N. Bischel

Acknowledgements: Healthy Davis Together, Healthy Central Valley Together, UC Davis Civil and Environmental Engineering

Degree Objective: M.S. (2024)

Abstract:

Wastewater-based epidemiology (WBE) can serve as a useful tool to provide insight into health information about communities, though less is known about subcommunity trends in wastewater data. This project is conducting a retrospective study using SARS-CoV-2 concentration data collected between September 2021 and September 2022 in Davis, California, to assess sub-sewershed trends and evaluate health equity in WBE as it relates to choosing adequate sampling locations. The goal is to build enduring capacity for wastewater monitoring that effectively captures data across all populations within a community, considering an array of spatial and demographic factors.

To assess population distributions within each sampling zone, Census data will be used. Populations can be analyzed spatially by factors such as age, number of occupants, race and ethnicity. Selecting the appropriate indices and recognizing areas of overlap can be used to identify particularly marginalized groups. The wastewater data can then be analyzed alongside the COD Census data to illuminate community trends. Future research will focus on determining whether HDT sampling captured spatial and demographic trends within COD at subregional levels in hopes of improving coverage during future sampling efforts and subsequently, informing more rapid public health responses in Davis and beyond.

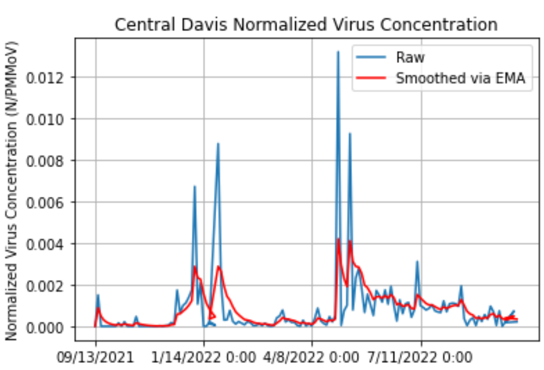


Figure 1: Example Normalized SARS-CoV-2 Conc. Profile

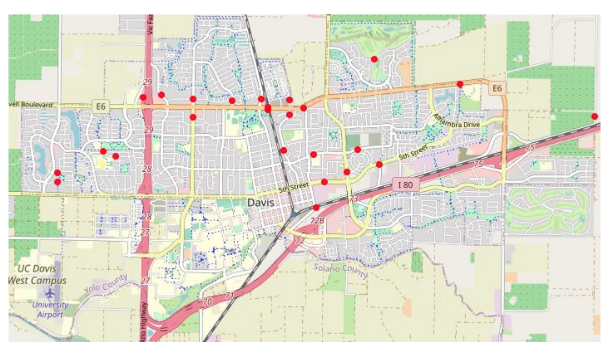


Figure 2: COD sampling locations.

Title: Targeted, Suspect, and Nontargeted Chemical Assessment of California Drinking Water

Presenter: Berkley Anderson (bnaanderson@ucdavis.edu)

Author(s): **Gabrielle P. Black[1]**, Berkley Anderson[1], Guochun He[2], Luann Wong[1], Chris Alaimo[1], Guillemette Calderwood[1], Brittany Saleeby[1], Michael S. Denison[2] and **Thomas M. Young**[1]

Advisor: Thomas M. Young

Acknowledgements: Funded by the California Breast Cancer Research Program

Degree Objective: PhD – Civil and Environmental Engineering

Abstract:

Breast cancer rates vary across California and differential exposure to environmental contaminants via drinking water supplies is one possible causative factor. Known mammary gland carcinogens include a broad array of chemical classes including dioxins, disinfection by-products (DBPs), hormones, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), pesticides, polyfluorinated alkyl substances (PFAS), phenols, and phthalates; many of which are not routinely monitored in water supplies. In addition, endocrine disrupting chemicals (EDCs) that directly activate and/or enhance the activity of estrogen receptors (ERs) have also been linked to increased incidence of breast cancer.

This project aimed to systematically assess the presence of such contaminants in over 240 household tap water samples collected across 8 different public water systems in California and in various brands of bottled, canned, boxed, and refill station water. These public water systems were selected to represent a range of characteristics including different source water types (small surface water, large surface water, mixed surface and groundwater, and groundwater); historical breast cancer rates (hot spot vs. non-hot spot); and treatment processes.

Drinking water samples were analyzed using a broad suite of targeted chemical analyses and nontargeted chemical analysis using LC-QTOF-MS and GC-QTOF-MS processing and nontarget chemical identification workflows. Extracts were also analyzed for estrogen-receptor bioassay activity using the ER-based Chemically-Activated Luciferase Expression (CALUX) recombinant cell bioassay containing an ERalpha- responsive breast cancer cell line (VM7Luc4E2). The central objectives of this work were to identify any known mammary gland carcinogens, EDCs, and nontarget chemicals correlated with observed estrogenic activity in household drinking water and examine differences across diverse water systems in California.

[1]Department of Civil & Environmental Engineering, University of California, Davis, [2]Department of Environmental Toxicology, University of California, Davis

Title: Using Eddy-Covariance to Quantify and Partition Greenhouse Gas Fluxes at Uvas Reservoir, Morgan Hill, CA

Author: Corrin Clemons (cgclemons@ucdavis.edu)

Advisor: Holly J. Oldroyd

Acknowledgements: Santa Clara Valley Water District

Degree Objective: PhD (2nd year)

Abstract:

Fresh-water aquatic greenhouse gas (GHG) emissions are historically underestimated due to their difficulty to predict and measure. Surface flux emissions of carbon dioxide and methane are driven by complex biogeochemical and physical interactions influenced by environmental factors in the sediment, water column, and local atmospheric microclimate. To capture and characterize the full GHG emission profile, a study will begin in May 2023 at Uvas Reservoir, managed by Santa Clara Valley Water District in Morgan Hill, California whereby high-rate flux measurements will be collected using the eddy-covariance technique that provides an integrated flux for a relatively large spatial footprint over the water surface.

Ebullition, emission through bubbling, can comprise the most significant proportion of methane releases in eutrophic environments in Mediterranean climates yet is the most challenging to quantify due to its sporadic nature. Its high spatial and temporal variability renders traditional diffusive chamber point measurement techniques insufficient for total flux quantifications. By applying the eddy-covariance technique, this study will achieve the resolution essential to isolate ebullitive events. Flux partitioning will be performed through wavelet transformations of the high-frequency data to generate wavelet coefficients, which emphasize abrupt deviations in the timescale data. Wavelet coefficients for the scalar values of temperature, water vapor density, and carbon dioxide concentration will be plotted against those for methane to determine the similarity between the turbulent exchange of these quantities. Homogenous methane diffusion promotes scalar similarity in the atmosphere, allowing these events to fall on a line, but ebullition events heterogeneous in space will create scalar dissimilarity and fall away from the line. This flux partitioning method effectively isolates and emphasizes the significant role of ebullition in total methane emissions, while generating values for diffusive methane fluxes similar to those measured by point chambers. Future work in this area will incorporate these findings with simultaneous ongoing limnological studies to better understand the conditions and mechanisms driving GHG fluxes in fresh-water environments over longer timescales.

Title: Tracking Antarctic meltwater in the Southern Ocean

Author: Drew Friedrichs (amfriedrichs@ucdavis.edu)

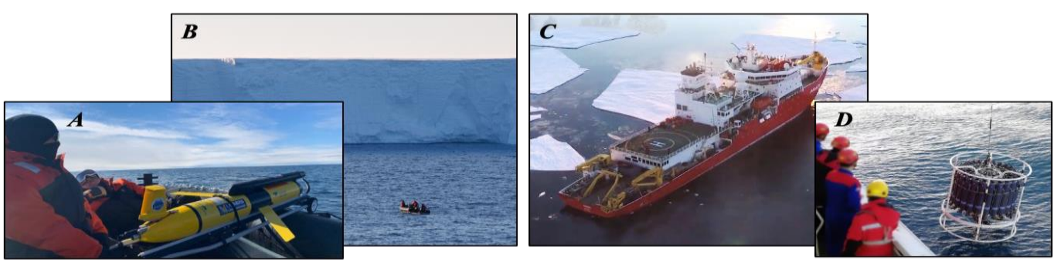
Advisor: Alex Forrest, Holly Oldroyd

Acknowledgements: Korean Ministry of Oceans and Fisheries, New Zealand Antarctic Science Platform

Degree Objective: Environmental Engineering PhD (2023)

Abstract:
Meltwater from the Amundsen Sea sector of Antarctica (100-135°W) accounts for 10% of global sea level rise and contains enough grounded ice to raise sea levels by another full meter. It is thus concerning that ice loss from these glaciers is accelerating. Due to the extreme nature of this location, most monitoring has been accomplished through remote sensing, including the observation of an acceleration in glacial discharge and a retreat of glacial grounding lines. However, with improvements in ocean-going ice breakers and autonomous underwater robotics, the ocean beneath Antarctica' s floating ice margins is now accessible.

My project uses ship- and autonomous underwater glider-based measurements of physical oceanography to describe and quantify the behavior of seawater near Antarctica's melting ice. We collect detailed, *in situ* measurements of ocean temperature, salinity, oxygen, and turbulence near massive floating ice shelves (see images below). We are able to identify the amount of heat available for melting, as well as the amount of glacier meltwater that has been mixed back into the water column. This helps confirm the theory that the fastest melting regions of Antarctica are those exposed to warm ocean water, which melts the ice from below. We are pushing the boundaries of what is possible with autonomous robotics, having completed the first successful autonomous glider mission to collect turbulence measurements beneath an ice shelf (Friedrichs et al., *Comm. Earth & Envir.*, 2022). We currently operate two gliders based out of the Tahoe Environmental Research Center, with development and testing occurring here in Lake Tahoe. We dream of operating a fleet of robots that are constantly documenting the impacts of climate change in all corners of the globe.



A: Autonomous underwater glider with turbulence instrument package. B: Zodiac operations near Drygalski Ice tongue. C: Research Vessel Ice Breaker Araon (Korean Polar Research Institute). D: Oceanographic profiling from the Araon.

Title: Manganese biomineralization by *Pseudomonas putida GB-1*

Author: Eleanor Fadely (ecfadely@ucdavis.edu)
Gaitan Gehin (ggehin@ucdavis.edu)

Advisor: Jasquelin Peña

Acknowledgements: Center for Bio-mediated and Bio-inspired Geotechnics (CBBG), Swiss National Science Foundation (SNSF)

Degree Objective: PhD (2026), PhD (2024)

Abstract:

Manganese (Mn) biomineralization is a ubiquitous biogeochemical process involving the enzymatic oxidation of aqueous Mn(II) to solid-phase Mn(III,IV) oxide minerals by microorganisms. Manganese oxides (MnOx) are potent solid-phase oxidants and scavengers of trace metal(loid)s, with the ability to significantly impact various geochemical cycles (e.g., carbon, nitrogen). Furthermore, biogenic MnOx can react with contaminants, making them a sustainable and cost-effective option for *in situ* or *ex situ* remediation and water treatment. However, despite recent advancement in Mn biomineralization studies, the biological processes and mechanisms leading to MnOx precipitation remain poorly understood. Further, it is not known how the physical and chemical heterogeneity of porous media environments influence the rate and extent of Mn biomineralization in natural and engineered systems.

We aim to improve our understanding of Mn biomineralization by investigating the model Mnoxidizing bacterium *Pseudomonas putida* GB-1 at the molecular scale, bacterial population scale, and soil pore-scale. Using fusion gene reporter and epifluorescence microscopy, we follow the activation of the Mn oxidases encoding genes in response to Mn(II). Our findings suggest that the presence of Mn(II) significantly enhanced the gene expression, however, only in a subpopulation. Moreover, the subpopulation increases with increasing Mn(II) concentration, resulting in faster MnOx precipitation rate. Using “soil-on-a-chip” microfluidic reactors integrated with optical microscopy and quantitative image analysis, we investigate the spatiotemporal variability of Mn biomineralization in a simulated soil pore space under flow. We observe that microbial colonies develop a variety of morphologies, MnOx precipitate on colony surfaces with extensive accumulation on colony edges in contact with pore fluid, and the rate of MnOx precipitation decreases over time. Our multiscale approach offers new insights into the timing of enzyme activity, spatial distribution of MnOx precipitates, and chemical conditions required to promote Mn oxidation by *P. putida* GB-1, which we will leverage to improve remediation and carbon sequestration applications in the field.

Title: Environmental performance of rice straw-based ash, electricity, and fertilizer

Author: Iyanuoluwa Filani (ifilani@ucdavis.edu)

Advisor: John Harvey & Alissa Kendall

Acknowledgements: California Rice Research Board

Degree Objective: PhD (2025)

Abstract:

A decline in the market shares of industrial supplementary cementitious material (SCMs), such as fly ash, necessitates the need to explore new SCM sources, particularly biomass resource. The environmental impacts of water leaching of harmful alkalis from rice straw to reduce slagging risks in biomass energy combustion equipment were evaluated based on life cycle assessment (LCA) modeling. The benefits of using two coproducts of liquid fertilizer from water leaching and rice straw ash (RSA) from combustion as value-added products in agricultural and concrete applications were considered. Hotspot analysis was done to determine processes with the highest Global Warming Potential (GWP) and how to optimize those processes to minimize overall impact.

Based on the LCA outcomes, RSA production from 1 tonne of straw without electricity generation would emit 286 kg CO_2 eq. (Figure 1). However, if used as fuel for energy production, the RSA emissions are reduced to 87 kg CO_2 eq. with 684 kWh of electricity produced based on the current California electricity grid mix. Greenhouse gas (GHG) credit from grid electricity substitution and Portland cement replacement results in a net GWP of -15 kg CO_2 eq. Drying, transportation, baling, and RO represent 39%, 28%, 16%, and 7% of the overall GWP (Figure 2). Water accounts for 46% of the total leaching GWP, while diesel and electricity account for 40% and 14%, respectively. Using electric conveyance systems instead of diesel-powered loaders can minimize GHG emissions in the leaching process.

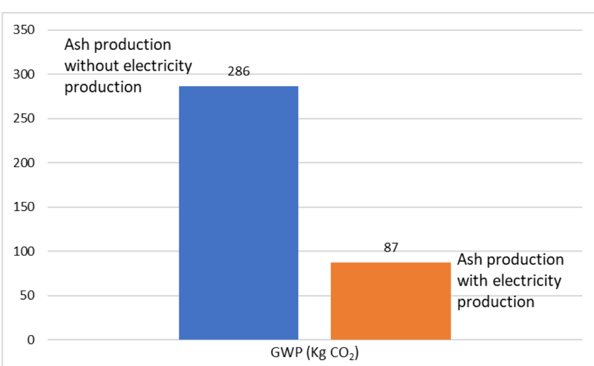


Figure 1: Impact per production route

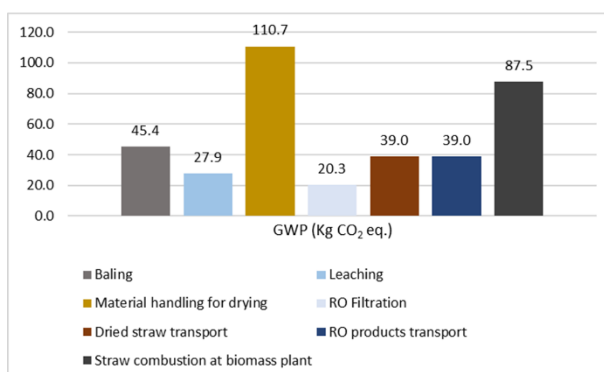


Figure 2: Impact per process

Title: Understanding Flow Feedbacks: Dissolution of Carbonate Rocks During Geologic Carbon Sequestration

Author: Janice Weldon (jweldon@ucdavis.edu)

Advisor: Veronica Morales

Degree Objective: PhD (2027)

Abstract:

The aim of this work is to better understand the circular feedbacks between dissolution reactions, structure, and flow in porous media. This work has applications in Geologic Carbon Sequestration, where carbon dioxide is injected deep into the subsurface, creating carbonic acid. The underlying structure of the porous media induces flow in the groundwater which in turn delivers the acid to the pore structure. The acid alters the pore structure through dissolution. These three elements form a feedback loop that can be modeled and studied.

Here, we show using k-means clustering that the flow feedback behavior can be divided into three regimes based on changes to the flow field channelization as the pore structure dissolves. Regulating heterogeneous samples grow more channelized, while regulating homogeneous samples become less channelized. Reinforcing samples retain the same level of channelization throughout dissolution. We also perform k-shortest path analysis of pore structures, using channel length/minimum channel width as a weighting scheme. Preliminary results suggest that the shortest path in heterogeneous (more channelized) samples is significantly less hydraulically resistive than the remaining 5. Conversely, the 5 shortest paths in homogeneous (less channelized) samples show relatively little difference in hydraulic resistance.

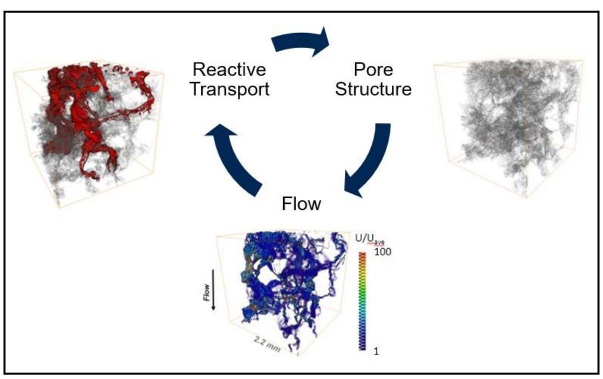


Figure 1: The feedback loop between pore structure, fluid flow, and reactive transport

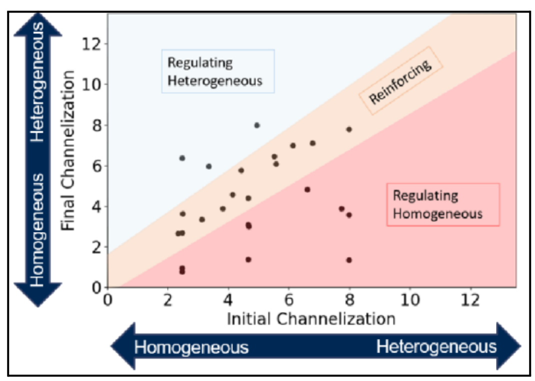


Figure 2: Flow regimes classified by change in flow channelization for samples undergoing dissolution

Title: Targeted Surveillance and Degradation Analysis of Respiratory Viruses in Wastewater

Author: Jordan Boeck

Advisor: Heather Bischel

Abstract:

Within the public wastewater (WW) system is a diverse array of microorganisms, including viruses that are pathogenic to human health and are secreted by infected patients. WW samples can be collected to measure the concentration of these viruses, which is reflective of current trends and strains circulating within the local population. Additionally, infectious virions in effluent pose a human risk when released into environmental waters, potentially causing an outbreak. Therefore, this project proposes developing several laboratory techniques to concentrate and measure multiple respiratory viruses inoculated into WW samples, and what physical, chemical, and biological parameters reduce their infectivity. Proteases secreted from WW bacteria are part of the biological parameter that remains understudied for virucidal properties. This proposed project seeks to determine if proteases could be advantageous for future bioremediation and sludge treatment purposes that are environmentally friendly and cost-effective. Overall, the knowledge gained from these studies will better equip wastewater-based epidemiological studies for the surveillance of future virus-associated pandemics. Lastly, enzymes secreted from bacteria have recently gained attention for bioremediation, and proteases could be utilized as virucidal agents in WW.

Title: Measuring Greenhouse Gas Fluxes from Uvas Reservoir: What is Stored in Your Reservoirs?

Author: Julianna Porraz (jporraz@ucdavis.edu)

Advisor: Holly J. Oldroyd and Alexander Forrest

Acknowledgements: Valley Water

Degree Objective: Water Resources Engineering (MS Candidate)

Abstract:

Atmospheric greenhouse gas emissions (GHGs) contribute to climate change, a global phenomenon resulting in long-term adverse effects [1]. Conclusively, it is documented that reservoirs are hotspots for CH_4 and CO_2 fluxes that are released into the atmosphere; however, there is little knowledge about the drivers of CO_2 and the impact that spatial and temporal variability play in flux emission rates[2]. Preliminary results show strong diurnal variability in both CH_4 and CO_2, with peak flux rates generally occurring during the daytime for CH_4 and during the nighttime for CO_2. For example, in June 2021 at Uvas Reservoir, CH_4 emissions increased from 0.056 mg m^{-2} h^{-1} at night to 0.82 mg m^{-2} h^{-1} during the daytime while CO_2 emissions decreased from -32.6 mg m^{-2} h^{-1} at night to -64.7 mg m^{-2} h^{-1}. These fluxes are also variable seasonally as well, where strong seasonal trends in CH_4 flux rates with peak emissions occurred during the warmer summer months when the reservoir bottoms had low dissolved oxygen concentrations and oxidation-reduction potential. Studies show that reservoirs can act as either a strong source or a sink for CO_2 [3,4]. Due to the lack of knowledge about CO_2, it is currently difficult to estimate the global emissions from reservoirs. This leads to inconsistent predictions of global climate models. My goal for the expansion of the project is to analyze CO_2 and gain knowledge of the spatial variability of CO_2 fluxes from drawdown sediments. I would like to further observe the role Mediterranean reservoirs, such as Uvas reservoir, have on CO_2 surface gas fluxes compared to other water bodies.

1 OAR US EPA, "Climate Change Indicators: Greenhouse Gases," Reports and Assessments, December 16, 2015, https://www.epa.gov/climate-indicators/greenhouse-gases.

2 B. R. Deemer and M. A. Holgerson, "Drivers of Methane Flux Differ Between Lakes and Reservoirs, Complicating Global Upscaling Efforts," *Journal of Geophysical Research: Biogeosciences* 126, no. 4 (2021): e2019JG005600, https://doi.org/10.1029/2019JG005600.

3 Bridget R. Deemer et al., "Greenhouse Gas Emissions from Reservoir Water Surfaces: A New Global Synthesis," *BioScience* 66, no. 11 (November 1, 2016): 949–64, https://doi.org/10.1093/biosci/biw117.

Title: Siderophore-mediated mobilization of manganese limits iron solubility in mixed mineral systems

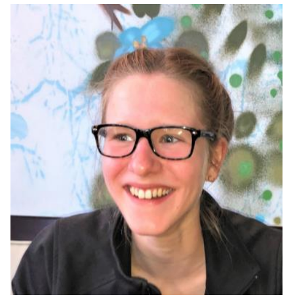
Author: Kyounglim Kang

Advisor: Jasquelin Pena

Acknowledgements: Civil and Environmental Engineering, University of California Davis, Davis, California, United States; Energy Geosciences Division, Lawrence Berkeley National Laboratory, Berkeley, California, United States

Abstract:

Recent laboratory and field studies show the need to consider the geochemistry of aqueous Mn(III) complexes by siderophores in manganese (Mn) and iron (Fe) geochemical cycling, a shift from the historical view that aqueous Mn(III) species are unstable and thus unimportant. In this study, we quantified Mn and Fe mobilization by desferrioxamine B (DFOB), a terrestrial bacterial siderophore, in single (Mn or Fe) and mixed (Mn and Fe) mineral systems. We selected manganite (γ-MnOOH), δ-MnO2, lepidocrocite (γ-FeOOH) and 2-line ferrihydrite as relevant mineral phases. We found that DFOB mobilized Mn(III) as Mn(III)-DFOB complexes to varying extents from both Mn(III,IV) oxyhydroxides, but reduction of Mn(IV) to Mn(III) was required for mobilization of Mn(III) from δ -MnO2. The initial rates of Mn(III)-DFOB mobilization from manganite and δ -MnO2 were not affected by the presence of lepidocrocite, but decreased by a factor of 5 and 10 for manganite and δ -MnO2, respectively, in the presence of 2-line ferrihydrite. Additionally, the decomposition of Mn(III)-DFOB complexes through Mn-for-Fe ligand exchange and/or ligand oxidation led to Mn(II) mobilization and Mn(III) precipitation in the mixed-mineral systems (~10 % (mol Mn/mol Fe)). As a result, the concentration of Fe(III) mobilized as Fe(III)-DFOB decreased by up to 50% and 80% in the presence of manganite and δ -MnO2, respectively, compared to the single mineral systems. Our results demonstrate that siderophores, through their complexation of Mn(III), reduction of Mn(III,IV) and mobilization of Mn(II), can redistribute Mn to other soil minerals and limit the bioavailability of Fe in natural systems.



Title: Biogeochemical properties and reactivity of wildfire ash: Implications for soil and water quality

Author: Libby Whelan (libwhelan@ucdavis.edu)

Advisor: Jasquelin Peña

Acknowledgements: The Environmental Health Sciences Center, Institute for the Environment, LBNL Belowground Biogeochemistry Science Focus Area, and LBNL LDRD Program.

Degree Objective: Graduate, 1st Year

Abstract:
Fire generates significant amounts of pyrogenic carbon, whose properties vary with the characteristics of the fire and the fuel. Therefore, we expect that the solubility of organic carbon and its accessibility to microbes, integral to whether carbon is maintained in the environment or respired as CO_2, will be influenced by the properties of the organic material generated during a fire. Consequently, ash will likely have a different potential of being a carbon source or sink than its underlying soil, and as it moves into the soil profile or nearby sources of water, it could change the potential of these environments to act as sources or sinks as well. Understanding the chemistry of ash will allow for more complete climate feedback models after wildfire events.

Additionally, wildfire ash can contain elements that are harmful to human health such as mercury, lead, and arsenic. Because ash is so mobile, it is important to understand the speciation of these elements within the ash to estimate risk should ash enter a water source as well as their fate and reactivity as the ash interacts with the land/soil surface.

This project uses elemental and spectroscopic analysis to advance an understanding of wildfire ash chemistry, which in turn helps to quantify risks associated with ash as it disperses in the environment. Measurements of ash and soil affected by the Glass Fire (2020, Napa and Sonoma Counties) show that there are differences in the leachable components between sampling location and type.

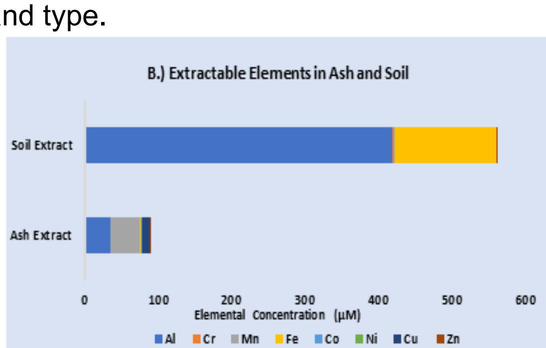


Figure 1: Concentration of select water-extractable elements as measured by ICP-MS

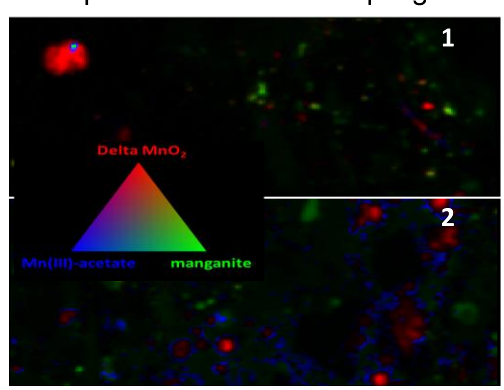


Figure 2: Speciation of manganese determined through PCA analysis and XANES spectra

Title: Viral Indicators & Removal Efficiency for Water Reuse

Author: Mel Johnson (Meljohnson@ucdavis.edu)

Advisor: Heather Bischel

Acknowledgements: Environmental Protection Agency

Degree Objective: PhD (2025)

Abstract:

As civilization strives to secure resources in the face of challenges such as climate change, globalization, and population rise; water crises have become increasingly prevalent across the globe. The southeastern region of the United States, in particular, has experienced a surge of drought patterns highlighting the need to improve our water resource management practices. To address these challenges, greater implementation of water reuse systems is necessary. These systems are used for irrigation of agriculture and landscaping, municipal water supply, power plant cooling, cleaning, industrial processes, and environmental sustainability projects such as the UC Davis Arboretum.

As water reuse systems gain greater attention, concerns have emerged over their safety, particularly with regard to pathogenic viruses. Due to their variability and small size, viruses are challenging to detect and monitor, making it difficult to assess the biological safety of reused water. Typically, facilities utilize indicators of virus contamination such as biological oxygen demand (BOD) and the presence of coliform bacteria to evaluate water quality. This project seeks to inform policymakers on water reuse safety by participating in a national cross-comparison study to identify better indicators for detecting pathogenic viruses in water treatment systems.

The study aims to accomplish this by taking 24-hour composite samples at several points throughout the wastewater treatment process (including primary influent, secondary treated effluent, and final effluent) and analyzing them through multiple methods such as plaques assays (for somatic and F-specific coliphage), molecular assays (using ddPCR to detect norovirus, enterovirus, and several others), flow virometry assays (to count virus-like particles), and processing water quality data taken at the treatment facility to develop a machine learning model to informs policy and best practices at the treatment facilities.

Title: Impacts of photovoltaic solar energy on soil carbon: A global systematic review and framework

Author: Noah Z. Krasner (nzkrasner@ucdavis.edu)

Advisor: Prof. Rebecca R. Hernandez

Acknowledgements: Electric Power Research Institute (EPRI); Argonne National Laboratory

Degree Objective: Ph.D. in Energy Systems (1st year)

Abstract:

Solar energy is anticipated to be the primary source of energy as early as 2050, and the greatest additions in global capacity are currently in the form of ground-mounted arrays. Increasing interest lies in understanding and anticipating opportunities to increase soil carbon sequestration across the footprint of conventional photovoltaic solar energy power plants; however, to date, studies of the relationship between soils and solar energy are limited to unique, localized study sites. We employed a systematic review to (1) identify what soil and soil-related properties interacting with solar energy infrastructure have been studied globally, and (2) assess the frequency and trends of soil and soil-related properties studied within this corpus. In all, this study provides a baseline and framework for assessing the feasibility of combining nature-based climate solutions with the climate change mitigation potential of solar energy.

Future work for this project includes (i) development of a conceptual model linking solar energy to soil carbon to inform future research, (ii) submission to Renewable and Sustainable Energy Reviews in June 2023, (iii) a long-term field study to validate findings, and (iv) production of a best-practices brief for practitioners and managers that's approachable and accessible.

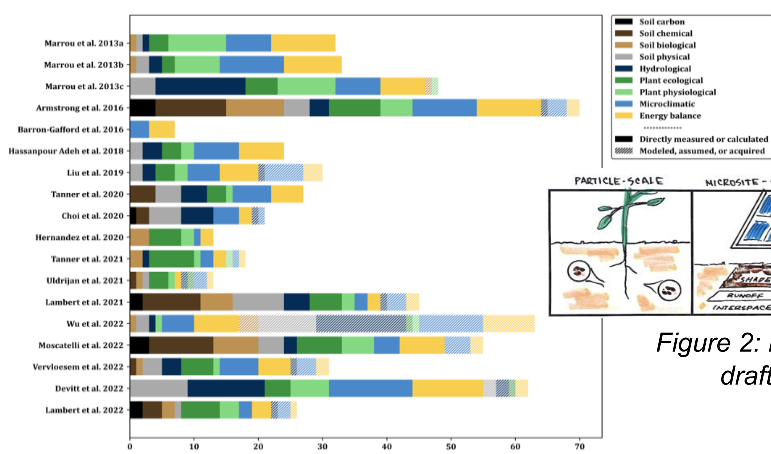


Figure 1: Results of experimental variable analysis, aggregated by study

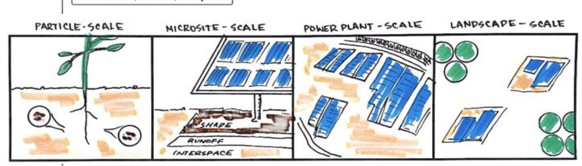


Figure 2: Four spatial scales used in draft of conceptual model

Title: Synoptic Hydroacoustic Assessment of CH_4 Pathways in Reservoirs and Associated Seasonality

Author: Ruth Thirkill (rthirkill@ucdavis.edu)

Advisor: Alex Forrest and Holly Oldroyd

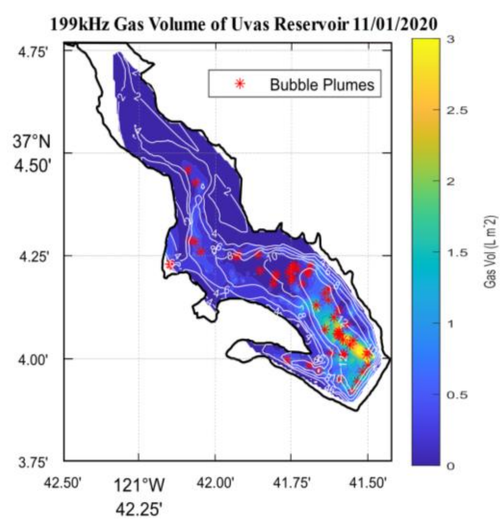
Acknowledgements: Valley Water and TERC

Degree Objective: PhD (2024)

Abstract:

Long strides have been made to explore the heterogeneity of CH_4 emission from lakes to the atmosphere at the whole-lake, regional and global scales. It is well documented that CH_4 fluxes from lakes and reservoirs are partitioned between diffusive and ebullitive (bubbling) flux pathways. Unlike diffusion, which is a slow process where much of the dissolved CH_4 is oxidized before reaching the surface, bubbles rise rapidly and can account for 50-90% of total emission at the water surface. High uncertainties exist in CH_4 emission estimates due to high spatial and temporal variability. In this study, 3 northern mesotrophic California reservoirs were hydro-acoustically surveyed to investigate the spatial and temporal variability of free gas stored in the sediment matrix and assess related ebullition patterns. Acoustic measurements revealed that there exists a temporal variability in the spatial distribution of sediment gas content that is linked to water depth and the duration bottom sediments remain anoxic during the stratified season. Furthermore, multi-year surveys demonstrated that significant spring off-gassing events occur during transitions between low and high-water storage year (e.g. sediment rewetting). Finally, this study demonstrates that it is possible to synoptically capture the spatial distribution of sediment gas and ebullition sites using sonar technologies, which combined with sediment and water body characteristics provides insight into the processes that regulate CH_4 emissions from inland waters.

Figure SEQ Figure * ARABIC 1.
Distribution of gas present in surficial sediments of Uvas Reservoir. White depth contours are included in meters.



Title: Remote sensing as a management tool for cyanobacteria blooms in inland waters: from multispectral to hyperspectral

Author: Samantha Sharp, P.E. (ssharp@ucdavis.edu)

Advisor: Dr. Alexander Forrest and Dr. Geoffrey Schladow

Acknowledgements: NASA, Tahoe Environmental Research Center (TERC)

Degree Objective: Ph.D. (Fall 2023)

Abstract:

Cyanobacteria Harmful Algal Blooms (HABs) and their associated toxicity are a leading concern for inland water resource managers and are increasing on a global scale. Remote sensing tools utilizing multispectral data have been developed to detect cyanobacteria in aquatic systems. Due to the extensive spatial coverage and frequent data availability of satellite-based sensors, multispectral remote sensing tools have demonstrated utility for monitoring, understanding, and managing these blooms. However, multispectral remote sensing tools are limited for monitoring HABs because they measure the relative abundance of cyanobacteria but do not indicate if the cyanobacteria present are cyanotoxin-producing genera. Upcoming satellite missions planned for this decade including NASA's PACE, GLIMR, and SBG missions may support the identification of cyanobacteria genera by exploiting the high spectral data domain. The additional data collected by these hyperspectral sensors will allow for the development of more sophisticated cyanobacteria detection algorithms. We evaluate the performance of cyanobacteria genera differentiation algorithms using precursor datasets in support of these upcoming hyperspectral missions. In situ measurements of lake optical, biological, chemical, and physical properties are used to characterize cyanobacteria blooms in hypereutrophic Clear Lake, CA, USA. Clear Lake offers a good study site for cyanobacteria differentiation algorithms because it supports large, diverse algal and cyanobacteria populations. Data collection occurred during 12 field events in 2021-2022 across all seasons. Three field events were conducted concurrently with hyperspectral data acquisitions from the DESIS sensor on the International Space Station (SBG-precursor data). The results of this study will support the development of future tools utilizing satellite-based imaging spectroscopy data to identify the cyanobacteria genera present in a bloom, and thus the potential for cyanotoxin production. This outcome – the ability to quickly characterize a cyanobacteria bloom at a low cost – will have enormous benefits for public health.

Title: Measurements of Turbulent Fluxes over a Forested Slope Terrain

Author: Ting Diane Wang (tdwang@ucdavis.edu)

Advisor: Holly J. Oldroyd

Degree Objective: 2^{nd}-Year PhD

Abstract:

Humans spend most of their lives in the atmospheric boundary layer (ABL), and the bottom 10% of the ABL is the surface layer, extending from the surface up to a height of 10 to 20 meters. Characterized by wind shear, temperature, and humidity differences between the surface and the atmosphere, the surface layer transfers momentum, heat, and moisture between the air and the underlying surface through turbulent mixing. However, a variety of factors may influence surface properties. For example, 'complex' terrain features usually entangle the near-surface processes, i.e., the terrain is not level and is covered with different types of vegetation, causing interactions among flow processes at a wide range of scales. Buoyanctly-driven slope winds due to radiative surface heating could transport air pollutants and affect mountain weather. Forest canopies are significant sources and sinks of heat and momentum fluxes between the surface and the atmosphere above. Quantification of net flux exchanges has significantly motivated turbulence studies over forested slopes. This study uses observations of turbulence measurements at multiple levels to characterize the mean and turbulence structure of slope flows impacted by forest canopies. The near-surface nonconstant-flux layer for slope winds violates the underlying assumption for the Monin-Obukhov similarity theory, which provided a basis for parameterizing near-surface turbulent flux transport in most numerical models. Quantifying the daytime near-surface flux transport and turbulent motion structures with observations over forested slopes could help to understand the fundamental physics and improve the existing surface-layer parameterizations in turbulence modeling.

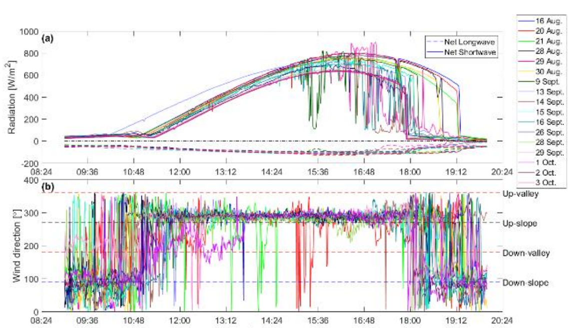


Figure 1: Time series showing (a) net shortwave and longwave radiations and (b) wind directions.

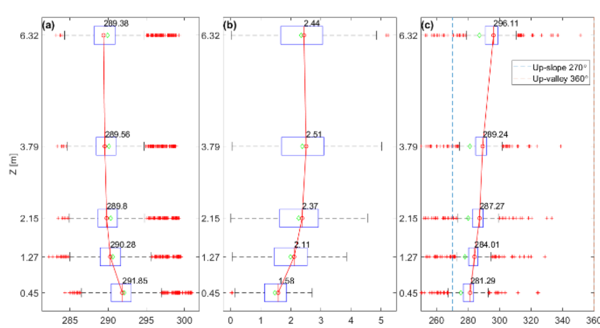


Figure 2: Box plot for (a) temperatures, (b) streamwise velocities, and (c) wind directions.

Title: Turbulence Modeling of Katabatic Flow over Sloping Mountains

Author: Yicheng Li

Advisor: Holly Oldroydd

Acknowledgements:

Degree Objective: Ph.D. (Second Year)

Abstract:

The atmospheric boundary layer (ABL) is the lower portion of the atmosphere in contact with the surface of Earth. It is turbulent and characterized by rapid changes in wind speed and direction. Katabatic winds are generated by the thermal alteration of inclined surfaces, especially in complex terrains like mountains and glaciers. However, accurately predicting their impact is difficult due to complex dynamics and challenges in measuring over sloping terrain.

The focus of this study is on using a modified 1-D Prandtl homogenous boundary layer Reynolds-Averaged Navier-Stokes (RANS) model to simulate katabatic flow in the atmospheric boundary layer. The Prandtl analytical model, which assumes first-order closure and constant eddy viscosity/diffusivity, provides a cornerstone for understanding slope flows. Our second-order 1-D homogenous boundary layer RANS model on a tilted surface has well-predicted wind speed and temperature. Additionally, our research indicates that the impact of the wall model is significant, particularly in simulating near-wall fluxes. To improve the understanding and simulation of land-atmosphere interactions for katabatic flow, we will utilize a modified local-MOST stability-correction function and use it in the wall of katabatic flows. This enables us to obtain simulation results of near-wall fluxes and help our future works on the Large Eddy Simulation (LES).

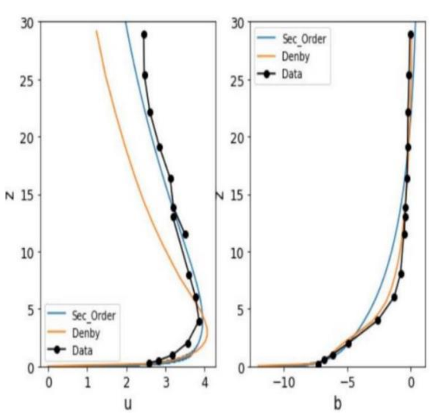


Figure 1: RANS results compared with observations

Title: Predicting dissolution in geologic porous media

Author: Zoe Kanavas (zkanavas@ucdavis.edu)

Advisor: Professor Veronica L Morales

Acknowledgements: NSF, AXA

Degree Objective: PhD (2023)

Abstract:

Developing an understanding of and predictive capabilities for reactive transport processes, namely dissolution, in porous media can improve the efficacy of reactive-barrier technologies for groundwater contamination remediation, petroleum reservoir stimulation for enhanced oil recovery, and long-term security of geologic carbon storage. Conventional methods for predicting dissolution behavior rely on large-scale transport and reaction metrics, overlooking pore-scale features that have been shown to control the spatial distribution of flow. To overcome this, we studied dissolution behavior in 26 real rock systems at the pore-scale. This work demonstrates that pore-scale flow complexity is critical to accurate qualitative (dissolution pattern) and quantitative (reaction rate) descriptions of dissolution reactions.

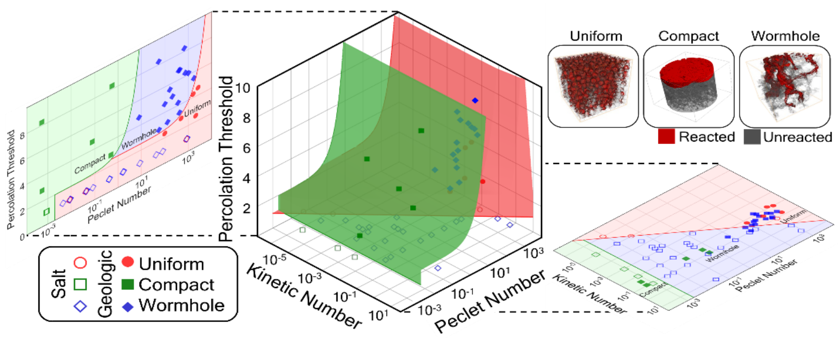


Figure 1. Phase diagram for dissolution behavior as a function of flow (percolation threshold), transport (Peclet number), and reaction (Kinetic number) metrics.

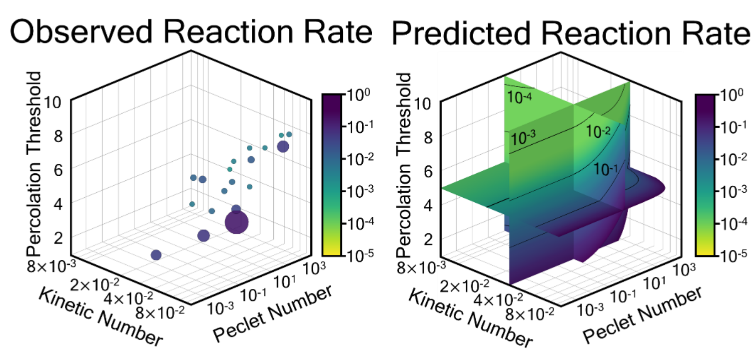


Figure 2. Observed and predicted reaction rate of a statistical model relating reaction rate as a function of flow (percolation threshold), transport (Peclet number), and reaction (Kinetic number) metrics.