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Deep Learning Gateways to Illuminating the Functional Potential and Ecosystem Impacts of Microbial Communities

We live in a world dominated by microbes. These microbial communities drive biogeochemical cycles that regulate current and future climate, impact ecosystem health and services, and have shaped the coevolution of life and Earth. Biology, and the biogeochemistry that is driven by it, is characterized by its complexity: in understanding life on Earth, in informing the bounds of potential life on other planets, and in our pursuit of long duration space exploration. This complexity of biological systems, and the challenges that come with it, is common to all fields of biology. The challenge in biological research is how to capture this complexity, with the high dimensionality and limited resources and data that are typically feasible to collect for any individual study. In this talk, I'll present my work applying machine learning and deep learning to microbial ecology, including strategies for overcoming the high-dimensional, low-sample-size conundrum of biology. I will present one such strategy in LookingGlass, a deep learning model of the 'universal language of life' that enables powerful deep learning models with limited data using transfer learning. I will detail examples of how these approaches can help us to map global microbial biogeography, identify causal drivers from observational data, evaluate the likelihood of unseen mutations, and tap into the functionally and ecologically important information contained in 'microbial dark matter'. Finally, I'll lay out my approach to empowering AI-driven insights in microbial ecology: from data discovery and high-throughput data generation in the lab, coupled to active model development, and culminating in validation in the field, resulting in a continuous feedback loop for high-throughput, data-intensive discovery for marine microbial ecology.

About the Speaker

Dr. Hoarfrost is an Assistant Professor at the University of Georgia in the Department of Marine Sciences and a faculty fellow in the Institue for AI. Her research focuses on developing AI and machine learning models and tools to better understand microbial communities in the marine environment and their impact on the marine carbon cycle. Her work combines this computational approach with experiments in the lab and in the field, with a particular focus on developing high-throughput and real-time empirical approaches that enable the scale needed for AI applications. Dr. Hoarfrost holds an AB in Biology from Dartmouth College, and a PhD in Marine Sciences from the University of North Carolina at Chapel Hill. Before joining UGA, she completed her postdoctoral work at NASA studying AI applications in astrobiology and space biology. Dr. Hoarfrost serves as a faculty mentor for the Frontier Development Lab, an applied AI research accelerator, leads the NASA Self-Driving Lab analysis working group, and is the Southeast regional node leader for the Ocean Carbon Biogeochemistry marine carbon dioxide removal (mCDR) working group. She is also the former Chief Scientist and co-founder of the climate tech company Fathom Carbon, and remains active in entrepreneurship and entrepreneurship mentoring.