Current Research Projects in Computational Biogeochemistry

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The computational biogeochemistry group in UVA's Department of Environmental Sciences http://www.evsc.virginia.edu/ tackles a wide range of interdisciplinary ocean and environmental science questions at the intersection of physics, chemistry, biology, and people. A particular focus is on natural and human-driven climate change and environmental impacts. The research spans from the open-ocean to the coasts and adjoining watersheds and from the shores of New England and the Virginia Eastern Shore to the Antarctic and Arctic.

The group's research is primarily computational and we interact extensively with several field programs as described below. Students often do a fair amount of data analysis, remote sensing, and numerical modeling work to address a broad range of biophysical, biogeochemical and ecological questions and themes. In several cases there are possibilities for students to participate in field work in conjunction with a primary computational research project.

A good place to start in developing some computational skills and background is a book that we developed from our hands-on graduate course (taught in Matlab)

Glover, D.M., W.J. Jenkins, and **S.C. Doney**, 2011: *Modeling Methods for Marine Science*, Cambridge University Press, Cambridge, UK, 592 pp., www.cambridge.org/glover ISBN-13: 9780521867832

UVA Environmental Resilience Institute (ERI) https://eri.virginia.edu/
The UVA Environmental Resilience Institute is a pan-university effort bringing together folks from natural and social science, engineering, architecture, and humanities to solve some of the toughest environmental problems. Our group focus within the ERI is primarily on coastal and climate resilience and more recently climate restoration and linkages of water, food, energy and carbon cycles.

Virginia Coastal Reserve (VCR) LTER https://www.vcrlter.virginia.edu/home2/
The Virginia Coastal LTER program is based on the VA Eastern Shore and led by UVA Environmental Science faculty with collaborators across the region. We are spinning-up a research program on water-column modeling, data synthesis, satellite and drone remote sensing, and field measurements (e.g., nutrient dynamics; oxygen; inorganic carbon system and acidification; ocean color, plankton, and water clarity).

Arctic biogeochemistry and carbon cycle
Our group is finishing a collaboration with scientists at the U. Alaska, Fairbanks on numerical models of the Gulf of Alaska and Arctic, focusing on how the regional

ocean carbon system is impacted by changing climate, reduced sea-ice, altered freshwater input from land, and rising atmospheric CO_2.

Palmer, Antarctic LTER (Long Term Ecological Research): http://pal.lternet.edu
The Palmer LTER program explores the ecological impacts of changing climate and sea-ice along the Antarctic Peninsula. The program has generated a rich marine ecological and biogeochemical dataset from plankton to penguins and whales over nearly three decades, with ship-based data and more recently mooring and robotic glider data and satellite remote sensing. Our group leads an active research component leveraging food-web, biogeochemical, and regional ocean-ice biophysical synthesis, modeling and remote sensing to address the program's overarching science questions.

North Atlantic Aerosols and Marine Ecosystems Study (NAAMES)
https://naames.larc.nasa.gov/
Our group led a marine ecosystem and biogeochemical modeling component within the NASA funded NAAMES project, which aimed to better understand the controls on ocean ecosystem dynamics over the annual cycle as well as ecosystem controls on biogenic aerosols in the marine troposphere. NAAMES completed four field campaigns combining ship-based, autonomous float, and airborne sampling. Our group is still involved in: 1) using NAAMES data to evaluate existing regional and global models, and 2) integrating field data, remote sensing, and numerical simulations to constrain plankton bloom dynamics.

Linking marine fisheries and ecosystems
We are collaborating with folks in the UVA Economics Department to characterize the impact of marine fisheries on large-scale ecosystems. This is a "big-data" project combining ship-transponder data (fishing locations, intensity) with satellite ocean color. This work opens up many avenues for future study on coupled human-natural systems for the marine environment.

Bermuda ocean time-series and bio-physical gliders http://bats.bios.edu/
http://magic.bios.edu/
UVA is developing a new collaboration with the Bermuda Institute of Ocean Sciences (BIOS) and UVA Statistics, and one set of projects involves working with BIOS scientists on analyzing and modeling their rich ocean time-series and biophysical glider data sets.

Ocean transient tracers
We are analyzing historical data and developing model simulations on tritium and helium isotopes (measures of ocean ventilation and circulation pathways) to better understand nutrient and oxygen dynamics. There is still lots more to do on this project involving the analysis of a new global data compilation and model simulations.

Marine Biodiversity Observation Network (MBON) http://www.marinebon.org/
http://www.marinebon.org/sanctuary-bon.html
We were part of a large, multi-institutional effort trying to dramatically change how we observe the ocean and then use the wealth of new data to inform marine resource management and conservation.

Ocean Acidification
We have a long-term interest in many aspects of ocean acidification from biogeochemistry and microbes to fisheries and socio-economics. One example is modeling studies of the US Northeast scallop fishery that link together water chemistry, scallop population dynamics, fishery operations, and physical and socio-economic drivers (e.g. climate change and acidification; human population and seafood demand; fuel prices).

Coastal Climate Change, Water Quality & Ocean Acidification
http://www.whoi.edu/sites/coastal_climate_change_solutions
We completed a field project working on Buzzards Bay, MA with an NGO-based citizen scientist program. The field component of the project has wrapped up but there are still opportunities for data analysis and modeling of water quality and its impacts (e.g., nutrient eutrophication, hypoxia, ocean acidification, water clarity, recreational shell-fishing and aquaculture). Recent projects include regional ocean warming, remote sensing of water clarity, drivers of shell-fishing trends, and acidification from freshwater inputs, eutrophication, and sewage discharge.

Ocean Carbon Observatory (OCO-2)
https://www.nasa.gov/mission_pages/oco2/index.html
We have funded projects to analyze and model data from the NASA OCO-2 satellite, which measures the atmosphere column carbon dioxide (CO_2) concentration. The objective of the OCO-2 mission is to improve estimates of CO_2 sources and sinks to the atmosphere including fossil fuel emissions and exchange with the land and ocean.

Community Earth System Model (CESM) http://www.cesm.ucar.edu/
We have a long-standing involvement with the Earth system modeling and the ocean and biogeochemistry components of the CESM. Research opportunities span from development and testing of new model parameterizations (e.g. marine ecosystem plankton dynamics; zooplankton migration; etc.) to analysis of the existing model simulations.

Carbon dioxide removal (negative emissions technologies)
We are part of a collaboration at UVA with folks in engineering and policy/economics to explore the potential impacts of carbon dioxide removal approaches (e.g., bioenergy with carbon capture and sequestration; direct air

capture). The work involves combining natural and social sciences and engineering utilizing as a framework an integrated assessment model of energy, technology, agriculture, and water systems.