OVERVIEW

As humans continue to emit greenhouse gases into the atmosphere, Earth's climate will continue to experience unprecedented changes. My research explores climate impacts in a modeling context, focusing on land-atmosphere coupling, terrestrial water cycling, climate variability, and vegetation-climate interactions. I further seek to better understand uncertainty in model projections of climate change through parameter sensitivity and optimization. More broadly, I strive to build interdisciplinary research connections that will help support collaborations across natural and social sciences. Below I outline my past and present research contributions, followed by my future goals for research and interdisciplinary collaborations.

PAST AND PRESENT CONTRIBUTIONS

Large Scale Hydrological Changes under Solar Geoengineering

During my PhD, I explored the climate impacts of solar geoengineering in a modeling context, focusing in particular on land-atmosphere interactions. I first investigated changes in the terrestrial hydrologic cycle using the Community Earth System Model (CESM). The interactions between vegetation water cycling and climate drive global and regional changes when uniform solar reductions are used to compensate elevated carbon dioxide (CO_2) levels (Dagon and Schrag, 2016, *J. Clim.*). I then expanded my modeling framework to utilize multiple large ensembles of simulations to examine how climate variability is impacted by solar geoengineering on a regional scale. I found that summer heat extremes decrease under solar geoengineering relative to a high-CO_2 climate, and in some cases, extremes decrease relative to present-day climate (Dagon and Schrag, 2017, *JGR-Atmos*). The coupling between soil moisture and daily maximum temperature was identified as a key mechanism in driving the variability response. Finally, I examined impacts on terrestrial ecosystems under solar geoengineering designed to hold anthropogenic radiative forcing fixed, relative to a mid-range future emissions scenario. Although potential changes in biodiversity are not completely avoided under solar geoengineering, I found that the outlook for conservation improves relative to a warming climate (Dagon and Schrag, *in revision*). Through my work on solar geoengineering, I interacted with a diverse research community that spanned natural and social sciences including economics, ethics, policy, and governance. As an emerging field, the tight-knit nature of this community allows for ample interdisciplinary interaction at conferences and workshops. These broad connections enriched my PhD research and will continue to provide dynamic collaborations in the future.

Reducing Uncertainty in Land Surface Models

Currently in my postdoc, I am collaborating with Community Land Model (CLM) scientists on a project to optimize model parameters for terrestrial hydrology and vegetation (Dagon et al., *in prep*). Land surface models are essential tools for capturing biosphere-atmosphere processes in the climate system. In recent years land model complexity has increased significantly through the addition of new physical processes and human influences on the land surface. With this complexity comes additional sources of uncertainty in climate projections. Many terrestrial parameterizations are uncertain or have high sensitivity to relatively small changes. Using machine learning techniques, I am working to optimize CLM parameter values for sensitive quantities, compare with global observations, and apply the results to better understand uncertainty in simulations of future climate. My work represents a novel approach to land surface model parameter estimation and helps bridge the gap between parameter calibration and model development. My fundamental motivation for this research is to better understand and communicate what is driving uncertainty in model projections of climate change.

FUTURE DIRECTIONS

Land-Atmosphere Interactions

A theme of my research thus far has been exploring the interaction and feedbacks between the land and the atmosphere in a modeling context on global and regional scales. This area of research invites collaboration with researchers across disciplines. Land-atmosphere interactions is also a sufficiently broad topic as to attract student interest in a variety of fields. At NCAR I participate in the CESM Land Model Working Group and collaborate with scientists working on data assimilation (both surface and satellite observations), essential steps to improving land surface models and climate models in general. I envision research projects involving global and regional model simulations, model validation with observations, and integration of field data into models. For example, I am planning to investigate how diffuse light impacts plant productivity on a regional basis where responses fundamentally differ due to canopy structure and composition. This is an example of a project that will integrate land-atmosphere modeling with terrestrial observations, and tie into my work on the climate impacts of solar geoengineering.

Climate Model Uncertainty

Understanding and quantifying uncertainty in climate model projections is a key priority for climate science research. I am interested in pursuing work on uncertainty quantification beyond my current work on land surface models. I plan to test my parameter uncertainty framework using a variety of model configurations, in order to investigate mechanisms in other parts of the climate system. I aim to build a framework which can be easily applied across different models, allowing for uncertainty work to be more universally pursued. These questions can be easily integrated into student research with a wide range of modeling tools. Aside from parameters, another important source of model uncertainty comes from model structure. To address questions of model structural uncertainty, I plan to explore the coupling of soil moisture dynamics with the atmosphere. Studying this interaction provides a way to isolate the regional effect of soil moisture on surface climate while comparing different methods of modeling soil moisture, an important mechanism to understanding and predicting extreme events like heatwaves and drought.

Balancing the Computing Requirements of Earth System Models

The world of climate modeling is constantly evolving. One of the challenges will be to balance computational requirements with scientific vision. At NCAR I utilize the Cheyenne supercomputer, a state-of-the-art computing infrastructure that allows climate modelers to run efficient simulations with a wealth of resources. However, as an undergraduate embarking on my first research experience, I learned to use a simple climate model that could be run on my laptop. Utilizing a range of computing resources is essential to managing student research and will be an important part of my research plan. In graduate school, I utilized two-dimensional models of the stratosphere to study the ozone hole, as well as an idealized model of ocean dynamics to investigate changes in El Niño. As part of my postdoc research, I am using machine learning techniques to build and train a neural network to act as a climate model emulator. This methodology allows for increased computational efficiency, which has many advantages. These projects, coupled with my experience with more complex models, will provide rewarding research experiences for students that reinforce computer programming skills in an applied Earth systems context.

Climate-Energy-Environment Partnerships

To have a measurable impact on climate science and policy, interdisciplinary collaboration and research is essential. Topics in energy and environmental science are natural linkages to physical climate science and are related areas that I am committed to including in my research vision. As a graduate student I was an active participant in the Harvard Graduate Consortium on Energy and Environment, which helped broaden my knowledge of energy and environmental issues and the policies surrounding them. Through this program I took courses on energy policy, energy technology, and the climate consequences of energy choices. These courses were offered outside of my home department and allowed me to interact with a diverse set of students. The collaborations and networking opportunities created through this Consortium were valuable to my research and career development. I aim to create a similar environment of climate-energy-environment seminars, collaborations, and opportunities. Applied climate modeling research that integrates energy and environmental issues is also very well suited for engaging students from a diverse range of backgrounds. As a result of my previous work at the Connecticut Department of Energy and Environmental Protection and my participation in the Graduate Student Science Policy group at Harvard, I also plan to keep science policy at the forefront of the work I do. I was once inspired by the ability to work at the interface of science and policy, and I suspect many students will be as well. Many of my research projects will provide students with natural linkages to real world applications, which is an exciting way to inspire a new generation of scientists.

COLLABORATIONS AND FUNDING

Climate science is not a singular discipline in that by nature it touches on so many different fields. My work will complement existing strengths and I look forward to future collaborations. My expertise in land-atmosphere interactions and Earth system modeling connects with existing work on land surface hydrology, climate dynamics, atmospheric aerosols, climate science and policy, and Earth surface processes. My work reaches across departmental boundaries with climate effects on ecosystems, model optimization and machine learning, and climate and environmental policy.

My research aligns well with two NSF funding divisions: Atmospheric and Geospace Sciences, and Earth Sciences. Other public funding opportunities existing in the DOE Climate and Environmental Sciences Division, EPA Climate Change Research, NASA Earth Sciences Division, and NOAA Climate Program Office. Faculty early career funding opportunities I would be eligible for include the NSF CAREER Program, DOE Early Career Research Program, and NASA Early Career Investigator Program in Earth Science. Scientific societies of which I am a current member include the American Geophysical Union and American Physical Society, both of which could serve as potential funding sources, including for student research and travel to conferences. My current institution, NCAR, supports Faculty Fellowships through the Advanced Study Program (ASP), and would be a potential source of funds for graduate students through internships and the ASP visitor program.