Ocean circulation in the subpolar North Atlantic — in particular that associated with the Atlantic Meridional Overturning Circulation (AMOC) — has been recognized as a source of large-scale decadal climate predictability. While skillful climate prediction on decadal time scales would be of great value to decision makers and planners, our conceptual understanding of the AMOC has been overturned in the last decade due to new observations and modeling studies. Given that climate projections consistently show that ocean circulation in the North Atlantic will change substantially in the coming decades, we need to reconcile model representation of coupled processes with observations. **My research program will contribute in two ways: (1) improved understanding of high latitude coupled climate, especially in the North Atlantic, leading to improved model representation and (2) mechanistic understanding of how ocean circulation can remotely influence climate on a range of timescales.**

My current postdoctoral research explores these themes, particularly how AMOC variability affects the amount of global warming. This project uses the Community Earth System Model (CESM) Large Ensemble — a 40-member collection of climate simulations with identical forcing and differing initial conditions — to examine the forced response of the AMOC to anthropogenic warming and the AMOC's internal variability. We find that random variability in Labrador Sea winds drives variability in the AMOC, which is in turn associated with higher surface temperatures at the edge of the sea ice edge and over Northern Eurasia. The temperature response near the sea ice edge requires a fully dynamic ocean, but the Eurasian temperature response may not. We connect oceanographic processes (water mass transformation) to atmospheric processes (surface wind and temperature response) and use cross spectral analysis and lead-lag regression to help establish causality. We are submitting these results soon to the *Journal of Climate*.

During my graduate studies, I investigated how mountain ranges affect climate, how continental geography affects tropical circulation and precipitation, and how ocean circulation interacts with climate. I have used a hierarchy of climate models to examine these topics. Removing a key physical process from a model (such as the interaction of water vapor and radiation) and replacing it with a simpler process (such as 'gray' radiation) allows insight into how those processes affect climate. It is equally important to test a hierarchy of model configurations that range from aquaplanets to realistic geography. Climates of aquaplanets have no longitudinal variation and adding a continent or mountain range breaks the zonal symmetry. At the other end of the hierarchy, removing a single geographic feature illustrates that feature's importance in an otherwise realistic configuration.

The usefulness of this approach is illustrated in my dissertation work that examines why deep water production occurs in the North Atlantic, but not in the North Pacific — a first-order characteristic of the climate system. I tested the idea that the Rocky Mountains were key for the North Atlantic location of deep water formation through their effect on Atlantic wind stress curl (first suggested by Bruce Warren in 1983) in a fully coupled, realistic configuration climate model with flattened Rocky Mountain orography. The AMOC is still present in the simulation without the Rocky Mountain orography, but surprisingly, a Pacific Meridional Overturning Circulation developed when the Rockies were removed. The changes in the oceanic overturning circulations in both basins are explained by changes in freshwater forcing from rivers, not by changes in wind stress forcing. This reorganization of the ocean circulation affects climate globally, including a shift in tropical precipitation. An implication of this research is that more study of freshwater forcing on the Pacific Ocean is needed. I am leading the submission of this research as a two-part article to *Journal of Climate*.

I plan to continue studying the interactions between climate and ocean circulation through three lines of investigation over the next few years. First, I plan to examine the local and remote influence of high latitude cloud feedbacks on North Atlantic deep water formation using a technique known as "cloud-locking." This technique uses high-frequency output of cloud-radiative quantities from a control climate simulation and then inserts them into the radiation scheme of a second simulation, effectively "locking" the radiative effect of clouds. By then applying a second forcing (e.g., increasing carbon dioxide or freshwater hosing) to a freely-evolving simulation and a cloud-locked simulation, the radiative impact of clouds can be assessed through comparison. While this technique has been applied to atmosphere-only processes, the influence of cloud radiative feedbacks on the ocean in coupled simulations has not been studied as widely.

Second, I will study the thermohaline circulation in the CESM Large Ensemble and Coupled Model Intercomparison Project 6 output using a water mass framework. In the high latitude North Atlantic, water sinks when it is forced by surface fluxes in the winter. The amount of surface water that becomes denser can be quantified through the calculation of water mass transformation, which directly connects atmospheric processes (through the surface heat and freshwater budgets) to oceanographic processes. As a diagnostic technique, water mass transformation makes an ideal process-oriented metric for model intercomparison, ensemble projects, and comparison to observations. I recently submitted a proposal on this topic to the NOAA Climate Program Office.

Finally, recent model simulations have shown that ocean processes in the high latitude North Atlantic are a source of predictability for tropical precipitation. My past research has examined connections between the AMOC and the Intertropical Convergence Zone (ITCZ), and I plan to study the evolution of tropical precipitation amount and location in response to North Atlantic ocean circulation variability. My past research in large-scale tropical dynamics alongside my more recent work will allow me to effectively study the connections of high latitude and low latitude climate.

While I will focus on these three topics over the next few years, I also plan to continue studying why the meridional overturning circulation has sinking in the North Atlantic but not the North Pacific. I intend to explore other theories for the North Atlantic location of deep water formation (e.g., ocean basin width, Mediterranean salt source) in a coupled model framework. I plan to study the influence of large-scale versus local freshwater forcing on climate through climate model simulations using realistic freshwater forcing patterns in both the North Atlantic and North Pacific.

In addition to my physical climate research, I have undertaken **interdisciplinary research** that includes social science methods as part of my doctoral participation in the National Science Foundation (NSF) Integrated Graduate Education and Research Traineeship (IGERT) Program on Ocean Change. As part of a group project for this NSF IGERT, I am studying how scientific knowledge is incorporated into sea level rise adaptation planning at the municipal level. A manuscript from this study has been completed and will soon be submitted to Global Environmental Change. Although my primary research goal is to examine the physical interactions of the ocean and the climate system, I expect to broaden my research portfolio to include interdisciplinary climate impacts research, collaborating with natural resource managers in academia and government agencies.

My research program will increase the mechanistic understanding of interactions between ocean circulation and the global climate system. This program would enhance and broaden the research being conducted at the Department of Atmospheric and Oceanic Sciences at Wisconsin. I can envision collaboration with Dan Vimont on coupled climate variability and climate prediction, with Larissa Back on the connections between tropical convection and ocean circulation, and with Steve Ackerman and Tristan L'Ecuyer on how atmospheric energy and ocean budgets covary. I would also plan to collaborate on research through the Nelson Institute for Environmental Studies.

The broad expertise on Atmospheric Science at Wisconsin makes it an ideal environment for collaborative climate science research, and aligns particularly well with the plan that is presented here. I am excited to explore the possibilities for developing a strong research team at Wisconsin.