Ph.D. Defense Announcement
Samantha Wills
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Ph.D. Defense

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Defense
ATS Large Classroom (101 ATS)

Post Defense Meeting
Riehl Conference Room (211 ACRC)

Committee:
David Thompson (advisor)
Eric Maloney
Elizabeth Barnes
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ON THE OBSERVED AND IDEALIZED ROLES OF THE EXTRATROPICAL OCEAN IN AIR-SEA INTERACTION AND CLIMATE VARIABILITY

The ocean is an integral part of the climate system, as it is capable of storing and releasing large quantities of heat across the air-sea interface, helping to regulate temperatures in the atmospheric boundary layer, and influencing atmospheric motions. Its closely-coupled interactions with the atmosphere system have wide-ranging impacts on the large-scale and local patterns of climate and weather variability from one region of the globe to another. The atmospheric response to variations in tropical sea surface temperatures (SST) is robust in both models and observations, and the influence of the tropical ocean on the large-scale atmospheric circulation is generally well-understood. Improvements in the resolution of satellite observations and numerical models over the past decade have also led to a series of advances in understanding the role of the ocean in extratropical air-sea interaction and climate variability. While the influence of the extratropical ocean can be relatively subtle and difficult to detect, recent observational and numerical studies provide a growing body of evidence suggesting that the extratropical ocean has a potentially more important influence on the atmospheric circulation on a wide variety of timescales.

Observational analyses exploit daily-mean data to re-examine the evidence for midlatitude air-sea interaction over the Kuroshio-Oyashio Extension region on subseasonal timescales, and important comparisons are drawn to a previous companion study over the Gulf Stream Extension region. Results indicate that during the boreal winter season, SST anomalies in both the Gulf Stream and Kuroshio-Oyashio Extension regions are associated with distinct spatial and temporal patterns of atmospheric variability that precede and follow peak amplitude in the SST field on daily-mean timescales. In particular, a very similar pattern of low pressure anomalies that develops over the warm SST anomalies is viewed as the most robust common aspect of the atmospheric \response" over both ocean basins. The least common aspect of the \response" is characterized by robust high pressure anomalies that develop over the North Atlantic and have a seemingly unique relationship to positive lower-tropospheric temperature anomalies generated over the Gulf Stream Extension region.

Partially motivated by the results from the observational analyses, a series of steady-state and transient numerical experiments are designed to analyze the observed behavior of atmospheric forcing due to extratropical ocean heating in an idealized configuration of the NCAR Community Atmosphere Model, Version 5.3 (CAM5.3). In this configuration, the atmosphere-only model simulates an idealized climate above a highly idealized water-covered "aquaplanet" with otherwise Earth-like characteristics. Perturbation experiments are performed to investigate the transient and equilibrium atmospheric circulation response to a sudden \switch-on" of heating at varying latitudes, where the heating is associated with a prescribed 1K SST anomaly of realistic size imposed onto a fixed (or unchanging) zonally-symmetric SST background distribution. The numerical experiments are intended to provide a simplified model framework to critically assess the influence of the ocean on the atmosphere, where the idealized configuration isolates one-way forcing from the "ocean" to the atmosphere at different locations across the globe.

Numerical analyses of the steady-state atmospheric response to latitudinally-varying fixed SST anomalies indicate the development of a robust and consistent equivalent-barotropic pattern of atmospheric circulation anomalies in all of the extratropical SST perturbation experiments, resembling the model's leading mode of internal variability. While it is not entirely unexpected that the atmospheric response to ocean forcing would project onto the leading mode of internal variability (given consistent findings in previous studies), it is unexpected that the atmospheric circulation response is seemingly independent of the latitudinal placement of the heat source. This result is explored further, and a possible explanation of the consistent steady-state atmospheric circulation response is discussed.