Ph.D. Defense Announcement
Casey Patrizio
June 2, 2021 at 1:00 p.m.

Casey Patrizio
Ph.D. Defense

Wednesday, June 2, 2021
1:00 p.m.

Defense
Virtually in Zoom (full link below)

Post Defense Meeting
Virtually

Committee:
David Thompson (Adviser)
David Randall (Co-adviser)
Maria Rugenstein
Richard Small (NCAR)
Jeremy Rugenstein (Geosciences)

Understanding the Role of Ocean Dynamics in Climate Variability

The ocean plays a key role in regulating Earth's *mean* climate because of its massive heat capacity, but also its heat transport by slow-moving circulations and other dynamics. In principle, fluctuations in such ocean heat transport can influence the *variability* in the climate, by impacting the sea-surface temperature (SST) variability and in turn the atmospheric variability through surface heat exchange, but this is incompletely understood, particularly in the extratropics. The goal of this dissertation is to clarify the role of ocean dynamics in climate variability, first focusing on the role of ocean dynamics in SST variability across the global oceans (Parts 1 and 2), and then on the impact of midlatitude ocean-driven SST anomalies on the atmospheric circulation (Part 3).

In Part 1, the contributions of ocean dynamics to ocean-mixed layer temperature variance are quantified on monthly to multiannual timescales across the globe. To do so, monthly ocean heat transport anomalies are estimated directly from a state-of-the-art ocean state estimate; and indirectly using the energy budget of the mixed layer with monthly observations of SSTs and air-sea heat fluxes. Consistent with previous studies, both methods indicate that ocean dynamics contribute notably to mixed layer temperature variance in western boundary current regions and tropical regions on monthly to interannual timescales. However, in contrast to previous studies, the results suggest that ocean dynamics *reduce* the variance of mixed layer temperatures throughout the Northern oceans on timescales longer than a few years.

In Part 2, the role of ocean dynamics in midlatitude SST variability is further understood using Hasselmann's model of climate variability, wherein SST variability is driven entirely by atmospheric processes. Motivated by the results in Part 1, here Hasselmann's climate model is extended to include the forcing and damping of SST variability by ocean processes. It is found that the classical Hasselmann model driven only by observed surface heat fluxes generally produces midlatitude SST power spectra that are too *red* compared to observations. Including observed estimates of ocean processes in the model reduces this discrepancy by decreasing the low-frequency SST variance and increasing the high-frequency SST variance, leading to a *whitening* of the midlatitude SST spectra. It is also shown that the whitening of midlatitude SST variability by ocean dynamical processes operates in NCAR's Community Earth System Model (CESM).

In Part 3, the atmospheric circulation response to midlatitude ocean-forced SST anomalies is explored. In particular, the extended Hasselmann model is used to isolate the oceanic and atmospheric-forced components of the observed SST variability in the Kuroshio-Oyashio Extension (KOE) region. The associated atmospheric circulation anomalies are diagnosed by lagged-regression of monthly sea-level pressure (SLP) anomalies onto the KOE-averaged SST anomalies, and their oceanic and atmospheric-forced components. Consistent with previous studies, a large-scale SLP pattern is found to lag the KOE SST anomalies by one month. Here it is shown that this pattern is linked to the oceanic-forced component of the SST variability, but *not* the atmospheric-forced component. The results hence suggest that the midlatitude ocean dynamical processes in the North Pacific influence the variability of the large-scale atmospheric circulation.

Topic: Casey Patrizio Ph.D. Defense
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