Ph.D. Defense Announcement
Andrea Jenney
August 21, 2020 at 10:00 a.m.

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Ph.D. Defense

Friday, August 21, 2020
10:00 a.m.

Defense
Virtually (details to come)

Post Defense Meeting
Virtually

Committee:
David Randall (Adviser)
Elizabeth Barnes (Co-adviser)
Kristen Rasmussen
Eric Maloney
Brooke Anderson (Environmental and Radiological Health Sciences)

Quantifying and understanding current and future links between tropical convection and the large-scale circulation

Tropical deep convection plays an important role in the variability of the global circulation. The Madden Julian Oscillation (MJO) is a large tropical organized convective system that propagates eastward along the equator. It is a key contributor to weather predictability at extended time scales (10-40 days). For example, variability in the MJO is linked with variability in meteorological phenomena such as landfalling atmospheric rivers, tornado and hail activity over parts of North America, and extreme temperature and rainfall patterns across the Northern Hemisphere.

Links between the MJO and atmospheric variability in remote locations are heavily studied. This is in part because the current skill of weather forecasts at extended time scales is mediocre, and because of evidence suggesting that the potential predictability offered by the MJO may not be fully captured in numerical prediction models. In the first part of this dissertation work, I develop a tool for these types of studies. The "Sensitivity to the Remote Influence of Periodic Events" (STRIPES) index is a novel index that condenses the information obtained through composite analysis of variables after a periodic event (such as the MJO) into a single number, which includes information about the life cycle of the event, and for a range of lags with respect to each stage of the event. I apply the STRIPES index to surface observations and show that the MJO signal is detectable and significant at the level of individual weather stations over many parts of North America, and that the maximum strength of this signal exhibits regionality and seasonality.

Tropical convection affects the extratropics primarily through the excitation of Rossby waves at the places where the upper-tropospheric divergent outflow associated with deep convection interacts with the background wind. In a future warmer climate, the strength of the mean circulation and convective mass flux is expected to weaken. A potential consequence is a weakening of Rossby wave excitation by tropical convective systems such as the MJO. In the second part of this work, I analyze a set of idealized simulations with specified surface warming and superparameterized convection and develop a framework to better understand why the mean circulation weakens with warming. I show that the decrease in the strength of the mean circulation can be explained by the slow rate at which atmospheric radiative cooling intensifies relative to the comparatively fast rate that the tropical dry static stability increases. I also show that despite a decrease in the mean convective mass flux, the warming tendency of the convective mass flux over the most deeply-convecting regions is not constrained to follow that of the global mean.

In the final part of this work, I consider how changes in the MJO and of the mean atmospheric state due to warming from increases in greenhouse gas concentrations may lead to changes in the the MJO's impact over the North Pacific and North America. Specifically, I show that changes to the atmosphere's mean state dry static energy and winds have a larger impact on the MJO teleconnection than changes to MJO intensity and propagation characteristics.