M.S. Defense Announcement
Ben Toms
November 12, 2018 at 2:30pm

Ben Toms
M.S. Defense

Monday, November 12, 2018
2:30pm

Defense
ATS Large Classroom (101 ATS)

Post Defense Meeting
Riehl Conference Room (211 ACRC)

Committee:
Susan van den Heever (advisor)
Elizabeth Barnes
Eric Maloney
Daniel Cooley (Statistics)

Interactions Between the Madden-Julian Oscillation and Mesoscale to Global Scale Phenomena

The Madden-Julian Oscillation (MJO) influences and interacts with atmospheric phenomena across the globe, from the tropics to the poles. In this two-part study, the interactions of the MJO with other phenomena across a broad range of scales are considered, including mesoscale convective structures within the tropics and global teleconnection patterns. While the two studies are distinct in the scales of the interactions they discuss, each highlights an aspect of the importance of interactions between the MJO and variability across a broad range of scales within the climate system. The study of such cross-scale interactions is important for fundamentally understanding our climate system, as these interactions can transfer energy between phenomena of starkly different spatial and temporal scales.

The first part of the study uses a cloud-resolving model, the Regional Atmospheric Modeling System, to consider the relationship between mesoscale convective structures within the Indo-Pacific region and the regional, intraseasonal anomalies associated with the MJO. The simulation captures the entirety of a canonical boreal summertime MJO event, spanning 45 days in July and August of 2016, during which the convective anomaly associated with the MJO propagated over the Maritime Continent. It is found that a cyclic relationship exists between the boreal summertime MJO and mesoscale deep convective structures within the Indo-Pacific region, as follows: increased cell longevity in the initial phases of the MJO, followed by increased cell number in the intermediate phases, progressing into increased cell expanse in the terminal phases. The bulk thermodynamic and kinematic anomalies of the MJO are closely related to the cyclic nature of convective cell expanse and longevity, while the number of convective cells appears to be tied to another source of variability not identified within this study. These findings emphasize that while the MJO is commonly defined as an intraseasonal-scale convective anomaly, it is also intrinsically tied to the mesoscale variability of the convective systems that constitute its existence.

The second part of the study quantifies the prevalence of the MJO within the overall climate system, along with its dependence on the background state of the atmosphere. It is well known that the MJO exhibits pronounced seasonality in both its tropical structure and extratropical teleconnections, and recent research has suggested that its tropical structure also depends on the state of the Quasi-Biennial Oscillation (QBO). We therefore first quantify the relationship between 300-mb geopotential anomalies and the MJO across the globe, then test the dependence of the relationship on both the meteorological season and the QBO phase using a derivative of cross-spectral analysis, magnitude-squared coherence. It is found that the global upper-tropospheric signature of the MJO not only exhibits pronounced seasonality, but also that the QBO significantly modulates the upper-tropospheric tropical and extratropical anomalies associated with the MJO. These results highlight the importance of considering the phase of the QBO in analyses related to either global or local impacts of the MJO, along with the importance of cross-scale interactions in governing the coupling between the MJO and teleconnections across the globe.

The defense will end with a brief discussion of how future work using deep learning, a subset of machine learning, may be able to help break the sub-seasonal predictability barrier within atmospheric science.