Ph.D. Defense Announcement
Jonathan Martinez
May 29, 2020 at 9:00 a.m.

Jonathan Martinez
Ph.D. Defense

Friday, May 29, 2020
9:00 a.m.

Defense
Virtual meeting link below

Post Defense Meeting
To be held virtually

Committee:
Michael Bell (Advisor)
Russ Schumacher
Christopher Davis (NCAR)
Thomas Birner (Ludwig Maximilians University)
Brooke Anderson (Environmental and Radiological Health Sciences)

Axisymmetric and asymmetric processes contributing to tropical cyclone intensification and expansion

This Dissertation endeavors to advance our understanding of tropical cyclones (TCs) by investigating axisymmetric and asymmetric processes contributing to TC intensification and expansion. Part I examines the extreme rapid intensification (RI) and subsequent rapid over-water weakening of eastern North Pacific Hurricane Patricia (2015). Spline-based analyses are created from high-resolution observations collected between 22–23 October during the Office of Naval Research Tropical Cyclone Intensity (TCI) experiment and the National Oceanic and Atmospheric Administration Intensity Forecasting Experiment (IFEX). The first full-tropospheric analysis of the dry, axisymmetric Ertel's potential vorticity (PV) in a TC is presented without relying on balance assumptions. Patricia's structural evolution is characterized by the formation of a "hollow tower" PV structure during RI that persists through maximum intensity and subsequently breaks down during rapid over-water weakening. Transforming the axisymmetric PV analyses from radius–height to potential radius–potential temperature coordinates reveals that Patricia's RI occurs "in-place"; eyewall heating remains fixed to the same absolute angular momentum surfaces as they contract in physical space, contributing to rapid PV concentration. Eddy mixing processes are inferred to concentrate PV radially inward of the symmetric heating maximum during RI and hypothesized to be a primary factor underlying the rearrangement of Patricia's PV distribution during rapid over-water weakening, diluting the PV tower while approximately conserving the absolute circulation.

Part II raises the question: do asymmetries facilitate or interfere with TC intensification?
An idealized, high-resolution simulation of a rapidly intensifying TC is examined to assess asymmetric contributions to the intensification process. The inner-core asymmetric PV distribution remains on the same

order of magnitude as the symmetric PV distribution throughout the intensification period. Scale-dependent contributions to the azimuthal-mean PV tendency are assessed by partitioning asymmetries into low-wavenumber (large-scale) and high-wavenumber (small-scale) categories. Symmetric PV advection and generation are approximately twice larger than asymmetric contributions throughout the intensification period, but the two symmetric contributions largely oppose one another in the eyewall region. Low-wavenumber advection concentrates PV near the axis of rotation during the early and middle stages of RI and low-wavenumber heating concentrates PV in the hollow tower during the middle and late stages of RI. Therefore, asymmetric processes produce non-negligible contributions to TC intensification and may indeed facilitate the intensification process.

Part III investigates the contributions of incipient vortex circulation and environmental moisture to TC expansion with a set of idealized simulations. The incipient vortex circulation places the primary constraint on TC expansion and in part establishes the expansion rate. Increasing the mid-level moisture further promotes expansion but mostly expedites the intensification process. One of the more common findings related to TC expansion in the literature illustrates a proclivity of relatively small TCs to stay small and relatively large TCs to stay large. Findings reported herein suggest that an initially large vortex can expand more quickly than its relatively smaller counterpart; therefore, with all other factors contributing to expansion held constant, the contrast in size between the two vortices will increase with time. Varying the incipient vortex circulation is associated with subsequent variations in the amount and scale of outer-core convection. As the incipient vortex circulation decreases, outer-core convection is relatively scarce and characterized by small-scale, isolated convective elements.

On the contrary, as the incipient vortex circulation increases, outer-core convection abounds and is characterized by relatively large rainbands and mesoscale convective systems. A combined increase in the amount and scale of outer-core convection permits an initially large vortex to converge a substantially larger amount of absolute angular momentum compared to its relatively smaller counterpart, resulting in distinct expansion rates.

GoToMeeting Information:

Jon Martinez PhD Defense
Fri, May 29, 2020 9:00 AM - 11:30 AM (MDT)

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