Ph.D. Defense Announcement
Louis Rivoire
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Ph.D. Defense

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Defense
ATS Large Classroom (101 ATS)

Post-Defense
Riehl Conference Room (211 ACRC)

Committee:
Thomas Birner (Adviser)
John Knaff (Co-adviser)
Michael Bell
Christopher Davis (NCAR)
Christian Kummerow
Karan Venayagamoorthy (Civil and Environmental Engineering)

ORIGINS AND IMPACTS OF **T**ROPOPAUSE **L**AYER **C**OOLING IN TROPICAL CYCLONES

Remote sensing data from GPS radio occultation reveal temperatures lower than climatological average over a layer several kilometers deep near the tropopause above tropical cyclones (TCs). This signal, here referred to as tropopause layer cooling (TLC), occurs primarily during TC intensification and on spatial scales of the order of 1000 km. TLC has been hypothesized to be the result of:

1) Adiabatic expansion in cloud tops that overshoot the local level of neutral buoyancy.
2) Long wave radiative effects near the cloud top.
3) Adiabatic expansion in the TC secondary circulation.

The relative role of these mechanism has not been quantified yet, perhaps pertaining to the large uncertainties and relative lack of vertical resolution of observational data sets and numerical modeling studies near the tropopause. Given the complex relationships between the thermal structure of the upper troposphere and the TC secondary circulation, determining which mechanisms are at play is paramount. TLC is also expected to destabilize the upper troposphere to convection and allow clouds to reach higher altitudes, likely leading to subtle but consequential changes in the secondary circulation and associated latent heating vertical distribution. Low temperatures near the tropopause can lead to in situ formation of cirrus clouds, which impact the radiative budget in the tropical tropopause layer. Lastly, low temperatures above convective systems have been linked to dehydration of the stratosphere, prompting the question of the role of TCs on the climate.

Mechanism 1 is discussed in light of existing literature and suggested to be of marginal importance. Mechanisms 2 and 3 are examined using a combination of observational and theoretical analysis, and numerical modeling. Radiative heating rates calculated using cloud properties retrieved by the A-train suggest that mechanism 2 may explain up to half of TLC in the inner core, but only marginal amounts of TLC at larger radii. While reanalysis data sets suggest that mechanism 3 may explain TLC, numerical simulations of TCs with higher resolution suggest that mechanism 3 does not act in a way consistent with the secondary circulation as is typically pictured, and may need to be revisited. Other mechanisms involving processes which violate gradient wind balance near the tropopause need to be formulated.

Finally, feedbacks between TLC, cloud structure, and TC dynamics are examined using parcel theory and idealized simulations. Parcel theory predicts that the TC thermal structure exerts a positive feedback on cloud top height during intensification, especially when convective entrainment is taken into account. While idealized simulations capture this general behavior, they exhibit other complex, transient behaviors indicative of tipping points in the interaction between clouds and their thermal environment.