Ph.D. Defense Announcement
Stacey Hitchcock
October 4, 2018 at 1:00pm

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Ph.D. Defense

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Defense
ATS Large Classroom (101 ATS)

Post Defense Meeting
Riehl Conference Room (211 ACRC)

Committee:
Russ Schumacher(Advisor)
Sue van den Heever
David Randall
Richard Eykholt (Physics)

On the Environments and Dynamics of Nocturnal Mesoscale Convective Systems

The 2015 Plains Elevated Convection at Night (PECAN) field campaign was motivated by unanswered questions about key processes in elevated mesoscale convective systems (MCSs) and the difficulty in accurately forecasting them. During the campaign, 15 MCS environments were sampled by an array of instruments including radiosondes launched by fixed and mobile sounding teams. Cluster analysis of observed vertical profiles established three primary pre-convective categories. Only one of these groups fits well with the common conceptual model of nocturnal MCS environments where equivalent potential temperature increases in an elevated layer with the onset of the low-level jet (LLJ). Post-convective soundings demonstrate substantial variability, but cold pools were observed in nearly every PECAN MCS case. However, stronger, deeper stable layers appear to lead to structures where the largest cooling is observed above the surface.

On 24-25 June 2015, a `bow-and-arrow' MCS structure was observed in an environment with strong low-level stability. Previous work on the mechanisms that support the structure in the arrow region (also sometimes referred to as rearward off-boundary development or ROD) has relied on a combination of a surface cold pool and large scale ascent provided by the interaction of a LLJ with a baroclinic zone. A horizontally homogeneous simulation initialized with a near-storm pre-convective PECAN sounding from the 24-25 June 2015 produces nearly the same MCS structure in the absence of a surface cold pool. Instead, outflow takes on several different forms in different regions of the MCS. Ultimately, the ROD (or arrow) is most likely supported by gravity wave amplified by vertical wind shear over the same layer, and maintained by persistent downdrafts.

The success of both MCS initiation and development of ROD despite the strong stable layer and idealized horizontally homogeneous initial conditions suggests that the interactions between convective outflow and a stable layer in a sheared environment are important in both of these processes. Very few studies to date have explored these interactions, and even less in 3D. A series of 2D and 3D experiments were designed to explore 1) What happens when a downdraft impacts a stable layer with and without shear? 2) What low-level shear profiles support MCS development in an idealized simulation with strong stability and why? 3) What shear characteristics are favorable for ROD development? Results indicate that strong low level shear is critical for sustaining convection, that low-level shear may be as important as stability in determining the effective inflow layer, and that upper level winds play a critical role in the development of ROD.