M.S. Defense Announcement
Jeremiah Piersante
Friday, May 22 at 10:00 a.m.

Jeremiah Piersante
M.S. Defense

May 22, 2020
10:00 a.m.

Defense
Virtually with information to follow

Post Defense Meeting
Virtually

Committee:
Kristen Rasmussen (Adviser)
Russ Schumacher (Co-adviser)
Peter Nelson (Civil and Environmental Engineering)

Synoptic through Mesoscale Environments of South American Thunderstorms

Subtropical South America east of the Andes Mountains is a global hotspot for deep convection owing to frequent mesoscale convective systems (MCSs) that contribute to over 90% of the region's rainfall and produce severe weather including large hail, flash flooding, high winds, and tornadoes. Investigations of these high impact systems through the Tropical Rainfall Measuring Mission (TRMM) satellite's precipitation radar (PR) determined that unique orographic, synoptic, and mesoscale processes initiate and maintain larger and longer-lasting MCSs in subtropical South America relative to the United States. Prior to the initiation of convection, the South American low-level jet guided by the Andes Mountains advects warm and moist air southward from the Amazon basin into the subtropics. A deep mid-level trough simultaneously approaches the mountains from the west in most cases, inducing dry mid- to upper-level subsidence flow and creating a strong capping inversion over the moist air mass. This cap is overcome via terrain-induced lift by the Andes foothills and the Sierras de Córdoba, a secondary mountain range in northern Argentina, resulting in explosive convection. These unique topographic features often act as a platform for "backbuilding" in which convection remains tied to the western terrain as storms propagate eastward and grow upscale; the quasi-stationary nature of MCSs inflicts considerable damage to property and agriculture in Argentina.

To improve the predictability and understanding of the physical mechanisms leading to dangerous MCSs in subtropical South America relative to those in the U.S., two studies within this thesis employ data from the recently conducted RELAMPAGO field campaign focusing on 1) the comparison of biases in warm-season Weather Research and Forecasting model (WRF) forecasts in North and South America and 2) a synoptic through mesoscale analysis of the driving factors behind upscale growth in subtropical South America. The first study uses WRF output over North and South America verified against Stage IV analysis and radiosonde observations to contrast magnitudes and sources of forecast error between continents. It is found that the cumulus parameterization, which is most active during the warm-season, governs biases in North American precipitation forecasts. While both continents featured a mid-level dry bias, the South American bias is greater. The second study uses TRMM PR, ERA5 reanalysis, high-resolution soundings and GOES-16 infrared brightness temperature data to identify synoptic and mesoscale phenomena that induce upscale growth varying in size and season. Synoptic forcing decreased from large to small systems and from spring to summer, suggesting that terrain-induced lift is more important in the summer. Furthermore, a case study of an MCS that exhibited rapid upscale growth during RELAMPAGO highlights the role of southerly return flow associated with the western edge of the 850-hPa lee trough on low-level convergence, vertical wind shear, and thus convection initiation. These two studies are of importance to the atmospheric science community as they enhance the understanding of some of the world's most violent thunderstorms in a region that has been notably understudied. Knowledge gained can also be applied to similar regions whose convection is also modulated by orography and provide a greater understanding of convective processes on a global scale.