M.S. Defense Announcement
Nathan Kelly
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OBJECTIVE ANALYSIS OF EXTREME PRECIPITATION EVENTS IN DIVERSE GEOGRAPHIC REGIONS

Extreme precipitation events are a focus of much research in the atmospheric science community today. These events are extraordinarily impactful to society, damaging critical infrastructure and in the worst cases taking lives. The factors that lead to these destructive events are not the same everywhere, dependent on each regions unique geography and climatology. There are two critical ingredients to rainfall: moisture and lift. However, there are many synoptic patterns that can combine these two ingredients in the right proportions to cook up an extreme storm. This thesis addresses the relationship between lift and moisture, and relates these two variables to the patterns that produce them, in a way that can be applied to any region of the world.

To accomplish this task the synoptic patterns must be categorized. This is done in an objective way, using a global reanalysis product (namely MERRA-2) so as to be applicable to any area around the globe. The period1980 to 2016 is analyzed, and an extreme precipitation event is defined here as an event that exceeds the 99.9th percentile of running 24-hour rainfall sums. Two domains are analyzed, one covering Argentina, and another covering northeast Colorado and part of the high plains to the north and east. Principal Component Analysis (PCA) is the objective method employed to investigate the variability within extreme precipitation events. PCA gives an indication as to what variables input into the analysis have the most impact on the variability of the dataset as a whole. This allows for an analysis of what variables are most different in different extreme events and what variables are about the same across events. PCA is performed on two different sets of variables at each grid point in the domains, two of which are selected for presentation here. The points selected are in northern Colorado and Córdoba, Argentina.

At the northern Colorado gridpoint it is clear that there are two very distinct modes of extreme 24 hour precipitation. The first is a convective mode that is characterized at upper levels by a large ridge aloft with a small embedded shortwave. The second is a synoptic mode commonly associated with the most intense snowstorms in the region; a cutoff low approaching from the southwest. The convective mode is associated with more precipitable water than the synoptic mode, whereas in the synoptic mode the upper air features are able to contribute significantly to the lifting of air and cause extreme precipitation with a relative dearth of moisture. In Argentina, the primary variability seems to be in the position of a surface trough in the lee of the Andes as a large scale upper level trough impinges on the Andes crest. The first mode has this lee trough more directly contributing to lift and allowing the low level jet and associated moisture to reach farther south. The second involves the position of the lee trough farther north, which allows the south Atlantic high to push flow from the Atlantic upslope into the Sierra de Cordoba, initiating convection. The overlap between 1-hour and 24-hour extremes is also explored for Argentina, confirming the convective nature of much of this precipitation and illustrating just how important these convective episodes are to the production of extreme precipitation.