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Prediction and Identification of Flash Flood Storms in Colorado. Part I: Attributes of Environment and Storm Evolution

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Heavy rainfall and hail frequently occur in association with intense, summertime convective storms that form along the foothills and eastern plains of the Colorado Rocky Mountains. Heavy rainfall amounts over localized regions can result in flash flooding in mountain communities and in the dense urban areas along the Front Range, disrupting traffic, causing damage to property and in extreme events, resulting in loss of life. Various approaches have been taken over the years to provide the best possible estimations of quantitative precipitation (QPE) and nowcasts and short-term forecasts of heavy precipitation (QPN and QPF, respectively) in order to assess the potential for flash floods over the 0-6 hr time period and to accurately model and predict streamflow increases and runoff. Ten Colorado flash flood and hailstorm events that occurred during the period from 2008-2012 are examined in detail in Parts I and II of this study to benchmark our current understanding of the attributes and evolution of flash flood events and determine how to improve our prediction and identification of those storms that are likely to produce heavy rainfall of short duration over very specific regions and basins sensitive to flooding.

In Part I of this study, we utilize instrumentation available from the Front Range Observational Network Testbed (FRONT) located along the Colorado Front Range. This testbed includes 5 dual-polarimetric Doppler S-band radars and a variety of operational and experimental surface, upper air, and satellite observing systems. These detailed observations provide high resolution observations of wind, temperature, moisture, stability, precipitation rate and accumulation. The events are characterized by environments with relatively high moisture content for the area, both in the boundary layer and at mid-levels and conditionally unstable atmospheres either over the plains or over the mountains, or both. Boundary layer and steering level winds were generally between 2.5 – 15 m/s (5-30 kts), so storms were either semi-stationary or not moving particularly fast. Numerous storms formed on these days, but the heaviest rainfall and flash flood resulted from merging storms, back-building storms, and the continual re-initiation of new storms over the same elevated terrain locations during the afternoon period. The collision of convergence boundaries over the plains and the enhancement of existing storms by convergence boundary passage resulted in the formation of large, semi-stationary storms that proceeded to rain heavily over the Denver urban area, and caused one fatality on one of the days. On another day, the storms that formed all seemed rather similar in character, but the rainfall associated with storms that passed over a recent fire burn area caused flooding in that sensitive land area. Identifying and improving the prediction of those specific storms that will produce the heaviest rainfall or case substantial flooding is challenging. Use of basic extrapolation techniques are not sufficient for prediction of heavy rainfall and flooding events (see Part II). Planned efforts include using the documented attributes of the ten heavy precipitation events to develop improved, location-specific, detection and prediction of heavy precipitation storms.