A momentous Hurricane Harvey (2017) evolved over the Gulf of Mexico and greatly impacted Texas and Louisiana with strong winds and historical rainfall amounts from 26 to 30 August 2017. The hurricane is studied with emphasis on its microphysical characteristics and their influences on its evolution. A sequence of high-resolution mesoscale simulations using an advanced research version of the Weather Research and Forecasting (WRF ARW) model is conducted. A three-dimensional variational (3D-Var) assimilation of conventional observations and airborne tail Doppler radar (TDR) radial velocity and reflectivity observations are performed using the NCEP Gridpoint Statistical Interpolation (GSI) system. It is found that the accurate simulations of Harvey’s track, structure, and rainfall before and after landfall are very sensitive to the choice of microphysical parameterization (MP) schemes and the types of observations assimilated. Specifically, the simulation with the LIN MP scheme leads to the best track and intensity forecasts, while different MP schemes lead to various hydrometeors in the simulations that have strong implications for the track of the hurricane through complicated interactions among hydrometeors, diabatic heating, and absolute vorticity tendency through potential vorticity anomalies. Also, assimilation of radar reflectivity data with GSI cloud analysis provides the most substantive improvements in track and intensity forecasts against the control simulation. Then, the simulations with cloud analysis are used to examine the microphysical characteristics and other controlling factors in order to analyze potential causes for the sudden onset of this outer rainband that produced massive rainfall amounts. Further diagnoses are made with high temporal (1 h) and spatial (3 km) High Resolution Rapid Refresh (HRRR) analysis. It is found that convective available potential energy (CAPE), convective inhibition (CIN) and components of diabatic heating such as sensible and latent heat fluxes are most important in characterizing the atmosphere during the development, duration and cessation of the strong outer rainband. Surface mesonet data also is used to examine the role that cold pools may have played in enhancing convective development within these rainbands. It is found that, although there are characteristics of cold pools revealed within the observation sets during rainband passage, there is not quite enough evidence to suggest that cold pools are influential enough to assist in the initiation of new convective cells within the rainband. Finally, statistical analysis through bootstrapping and stepwise multiple linear regression further prove that CAPE, a thermodynamic feature, and lower-level rain water mixing ratio (RWMR), an indication of liquid hydrometeor distribution, are the two primary variables that represent the state of the atmosphere during the extreme rainfall event.

Peter A. Saunders
Ph.D. Candidate

Supervisory Committee: Dr. Zhaoxia Pu, Dr. Edward Zipser,
Dr. Jan Paegle, Dr. Court Strong, Dr. Allen Zhao (NRL)

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10:00 am
110 INSCC
135 South 1460 East, Room 819 (WBB), Salt Lake City, Utah 84112-0110
Phone: (801) 581-6136 Fax: (801) 585-3681 Web: www.atmos.utah.edu