James Klinman Topic Proposal, Atmospheric Sciences, M.S.

Comparison between In-situ and Polarimetric Radar Observations of Hail in Convective Storms

Improvements to radar polarimetry, namely the introduction of dual polarization, have allowed for improved observations and forecasting of hail. However, there is a lack of direct comparison of radar variables, such as reflectivity and differential reflectivity, to quantitative in-situ microphysical measurements from hail storms. Additionally, there is a lack of in-cloud validation of hail predictors and distinguishing features that meteorologists use to nowcast and forecast hail. Average annual hail losses are $1.433 billion USD (Changnon et al. 2009), so improvements to our understanding of and prediction capabilities for hail are important to inform efforts to minimize losses. For any research or work that requires modeling hail, the accuracy in characterizing hail's microphysical properties is limited due to the small number of analyzed in-situ measurements (Martius et al. 2018). The objective of this project is to quantitatively analyze existing in-situ hail data along with radar data from the same storm volume. This will allow for better interpretation of polarimetric radar returns in order to learn how to better identify hail properties and the hail environment.

Between 1969 and 2003, the South Dakota School of Mines and Technology operated an armored T-28 aircraft capable of flying into convective storms containing up to 5 cm diameter hail. The data from these T-28 flights are valuable since they provide unique and one-of-a-kind in-situ in-cloud data on hail. Some of the T-28 data has been analyzed to support various research projects. For some examples, see Field et al. (2019), Schlatter (2003), and Cecchini et al. (2022). To expand on previous research projects and add to our knowledge on hail, this project aims to determine the best way to combine the radar and aircraft observations obtained during all the T-28 flights to understand the physical properties of the observed hail and compare calculated radar variables with in-situ observations. The T-28 aircraft had a High Volume Particle Sampler (HVPS) and Hail Spectrometer on board for its flights. The aircraft also housed numerous instruments to collect data including temperature, updraft speed, latitude, longitude, audio recordings, and liquid water content. Physical parameters of temperature, updraft/downdraft speeds, and liquid water content are of particular importance to understand the conditions that hail forms in and to improve our understanding of the storm structure at specific locations within the radar scans. The aircraft parameters will be visualized with the Airborne Data Processing and Analysis (ADPAA) software package. The System for OAP Data Analysis (SODA) processes the raw hydrometeor data and generates a file containing the particle size concentrations per a set time range. The particle size concentration is particularly useful for radar variable calculations. Code is being written in Python to help process and visualize the data. The Python code, along with the Lidar Radar Open Software Environment (LROSE), will also make it possible to show the relevant radar data and extract the radar variables to compare with calculated radar variables.

Comparing calculated radar variables to the observed radar variables will serve to improve and validate some of the techniques used to identify hail and mixed hail and rain regions from radar scans. With these improvements, hail forecasting and nowcasting could be done more accurately and with more confidence. This improvement to our ability to predict hail means that severe thunderstorm warnings can be more accurate and timely. Finally, for researchers modeling convective storms, the observations from the plane sensors will supply additional or improved information on hail properties so that assumptions can be minimized and parameterizations can be improved.