Comparison between In-situ and Polarimetric

Radar Hail Observations in Convective Storms

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Improvement to radar polarimetry, namely dual polarization, has allowed for improved forecasting of hail. However, there is a lack of direct comparison of radar variables, such as reflectivity and differential reflectivity, to quantitative in-situ measurements from hail storms. Additionally, there is a lack of in-cloud validation of hail predicting and distinguishing features meteorologists use to nowcast and forecast hail. 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 thus to better understand the microphysical properties of hail and how the storm conditions influence the formation of hail.

The South Dakota School of Mines operated an armored T-28 aircraft capable of flying into convective storms with up to 5 cm hail. While some of the T-28 flights have been analyzed to support individual qualitative analyses, most of the data still remains to be analyzed. The project’s methodology is to determine the best way to combine the radar and aircraft observations obtained during all the T-28 flights. The combined data set will be analyzed to 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 T-28 aircraft also housed numerous instruments to collect data including temperature, updraft speed, pressure, latitude, longitude, audio recordings, and liquid water content. Physical parameters of temperature, updraft/downdraft speeds, and liquid water content are of particular use to understand the conditions that hail formed 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 hydrometers are imaged by the HVPS and Hail Spectrometer and processed using the System for OAP Data Analysis (SODA). SODA processes the data to remove artifacts generated by streaking or shattered particles and characterizes the valid particles so that we can look at the image characteristics for the whole flight. SODA also generates a file containing the particle size concentrations per a set time range. The particle size concentration is particularly useful and is used in the radar variable calculations. In addition to particle size, the characterization of the particle's aspect ratios serves the dual purpose of improving our understanding of the hail’s shape and it improves the calculations as well. A source of useful data not yet processed are the audio recordings. They provide sharper “pings” when larger and more solid hail strikes the T28 windshield and more “mushy” quieter sounds for softer and smaller hail. Ideally, we can better determine the density of hail with this data and use it as supporting information while we process and analyze the rest of the data. Project programs will be further developed and can extract interesting data alongside developed software - all of which is or will be archived in a project software repository. One such program is capable of plotting aircraft tracks over the radar images and extracting the radar variables for the gates the aircraft flew through. Code is also being written to mask noisy and invalid data from the radar data. Another consideration we have to make with the radar data is to correct for any gates the aircraft was flying though at the time the scan passed through the aircraft location. To make sure we’re only using valid data, a correction will be applied to those gates. The project will use the LIDAR Radar Open Software Environment (LROSE) software to improve our radar plot producing capabilities. In particular, LROSE can create constant-altitude plan position indicators (CAPPI) and potentially merge radar scans from different radars. The CAPPI’s serve the purpose of interpolating the radar scan to a constant altitude for comparison to the aircraft sampling altitude.

All of this processing and analysis will be used to compare calculated radar variables to the observed radar variables, and it will serve to improve on 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. And for those of whom it’s important to know the microphysical properties of hail, such as people modeling convective storms, the observations from the sensors and probes will provide much needed information on hail properties. Plus, the radar variable calculations require fine tuning the parameters for hail properties. The fine tuning helps to draw extra information on which estimated parameters most accurately produce results matching the radar returns. In addition to the operational and research benefits this study will provide, it is important to improve our ability to predict hail so that more accurate and timely hail warnings can be shared. Average annual hail losses are $1.433 billion USD (Changnon, Changnon, and Hilberg, 2009), so improvements to our understanding of and prediction capabilities for hail are important to inform efforts to minimize losses.