UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

POLARIMETRIC RADAR SIGNATURES IN DAMAGING DOWNBURST−PRODUCING THUNDERSTORMS

A thesis

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

degree of

MASTER OF SCIENCE

By

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Norman, Oklahoma
2002

POLARIMETRIC RADAR SIGNATURES IN DAMAGING DOWNBURST−PRODUCING THUNDERSTORMS

A THESIS APPROVED FOR THE
SCHOOL OF METEOROLOGY

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Acknowledgements

First and foremost, I am indebted to my M.S. Committee for their support and encouragement. In particular, my Committee chair Dr. Alan Shapiro, Mr. Don Burgess, Dr. Kim Elmore, and Dr. Josh Wurman volunteered a considerable amount of time and energy in this endeavor.

I thank Mr. Curtis Alexander, Mr. Mike Coniglio, Mr. Scott Giangrande, Dr. Alexander Ryzhkov, Dr. Terry Schuur, and Dr. Dusan Zrnic for taking time to listen to my ideas, offer suggestions, and provide inspiration and ideas to improve upon this work.

My interest in downbursts began during my experience at the National Weather Service Warning Forecast Office in North Little Rock, Arkansas, and grew under Mr. Travis Smith at the National Severe Storms Laboratory. I am grateful for the early opportunity to develop and pursue my interest in this topic at both institutions.

The funding for this project was provided by the Federal Aviation Administration, and my graduate experience was facilitated by the Cooperative Institute for Mesoscale Meteorological Studies at the University of Oklahoma. I thank both groups for their continued support. The National Severe Storms Laboratory and its staff also provided excellent infrastructure and support. The National Center for Atmospheric Research and its staff provided invaluable assistance in obtaining and using the polarimetric radar data in this study. I am grateful to their staff who collect and distribute these data.

Mr. Curtis Alexander, Mr. Danny Cheresnick, and Mr. Cody Kirkpatrick cannot be thanked enough for their friendship and support. Mr. Jeff Cupo and Mr. Cullan Hudson entered my life late in the process, and can only be described as angels sent from above. I only wish I had met them sooner.

Finally, my parents, Richard and Ann Scharfenberg, cannot be thanked enough for fostering and encouraging my interest in meteorology from an early age. Along with my sister Karin McFall, their support has been undying, particularly in the last year of my M.S. work.

Table of Contents

List of Abbreviations, Acronyms, and Symbols

δ	Backscatter differential phase shift, measured in degrees
ϕ_{DP}	Differential phase shift, measured in degrees
λ	Radar pulse wavelength
$\rho_{HV}(0)$	Co−polar correlation coefficient
AGL	Above ground level, measured in units km
ARL	Above radar level, measured in units km
BZ90	Balakrishnan and Zrnic 1990a and 1990b
D	Particle diameter
K	Complex refractive index
K_{DP}	Specific differential phase shift, measured in units deg km^{-1}
N(D)	Number distribution of particles with diameter D
PPI	Plan position indicator radar scan
PR	Polarimetric radar
PRECIP98	Precipitation 1998 project
PRF	Pulse repetition frequency
PSD	Particle size distribution
R84	Rasmussen, et al. 1984
RHI	Range height indicator radar scan
S−Pol	National Center for Atmospheric Research S−band polarimetric radar
STEPS	Severe Thunderstorm Electrification and Precipitation Study
S87	Srivastava 1987

WB88	Wakimoto and Bringi 1988
WSR−88D	National Weather Service Weather Surveillance Radar 1988−Doppler
Z	Radar reflectivity factor, measured in units dBZ
Z_{DR}	Differential reflectivity, measured in units dZ

Abstract

Polarimetric radar (PR) data from several downburst−producing thunderstorms are examined. Very high local values of specific differential phase (K_{DP}) are frequently found to coincide with the first appearance of a divergent low−level radial velocity couplet. Considered along with high reflectivity factor (Z) and low differential reflectivity (Z_{DR}) values, this indicates the bulk presence of a hail and rain mixture at low levels within the downdraft column. These observations are corroborated by a decrease in co−polar correlation coefficient ($\rho_{HV}(0)$) toward the ground, indicating an increasing mixture of hydrometeor types.

Previous modeling studies show that melting hail is a large contributor to downward accelerations, enhancing wet microbursts. Wind tunnel studies state that melting hailstones form a water torus during their descent, with frequent shedding of water drops of various size. A local increase in K_{DP} is therefore expected, as shed drops produce a large number of new oblate hydrometeors. Bulk hydrometeor characteristics deduced from these PR observations are compared to these model and wind tunnel studies. It is surmised that diabatic cooling due to the phase change of melting hail is a large contributor to the development of these downbursts.