Dual Polarization Radar Winter Storm Studies
Supporting Development of NEXRAD-Based Aviation Hazard Products

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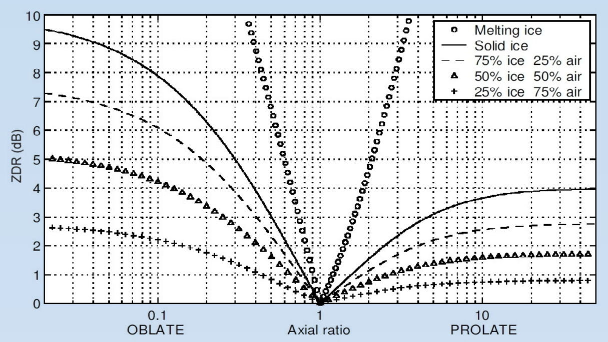
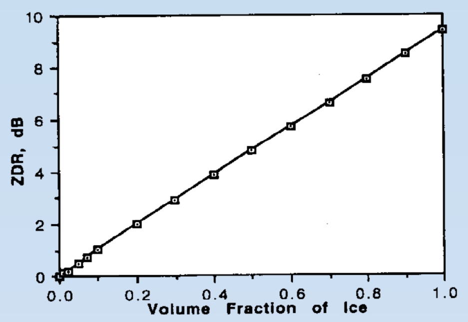
Objective

Study the dual polarization radar signatures of all variety of winter storms to relate the winter microphysical states and observed precipitation structures to usable metrics for inferring the presence of a supercooled water icing hazard.

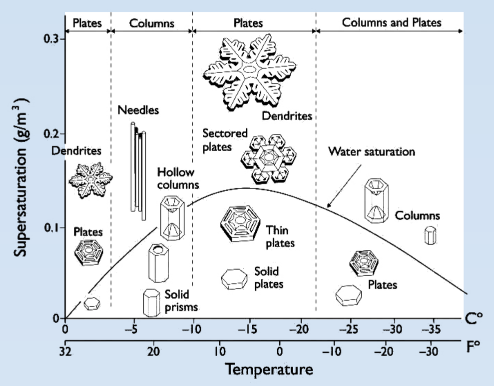
Interpretational Background



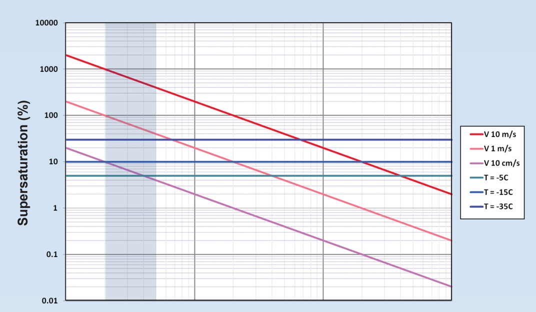
Plates and Dendrites (oblate) provide more return than needles (prolate) for equivalent ratios (Hogan et al., 2002)



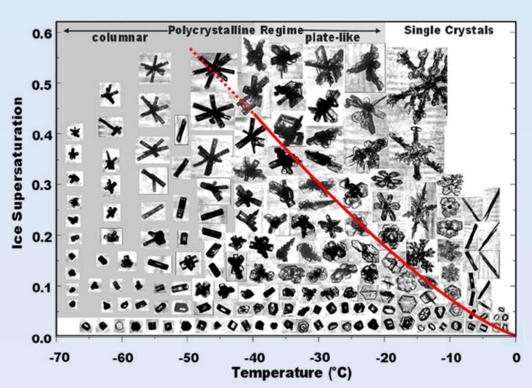
Dendrites (Category A) have a smaller volume fraction of ice than plates (Category B) and thus a smaller ZDR (Vivekanandan et al., 1994)



Simplified diagram of crystal habit



The existence of icing conditions depends on both updraft speeds and ice crystal populations (adapted from Korolev and Mazin, 2003)



Diffusion chamber results on crystal habit (Bailey and Hallett, 2009)

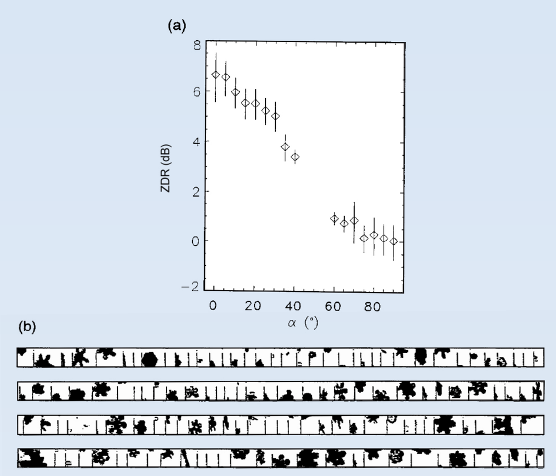
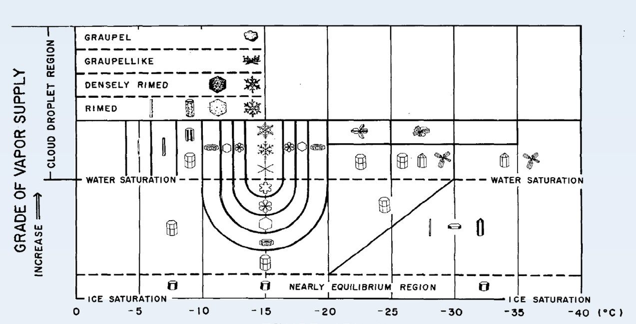
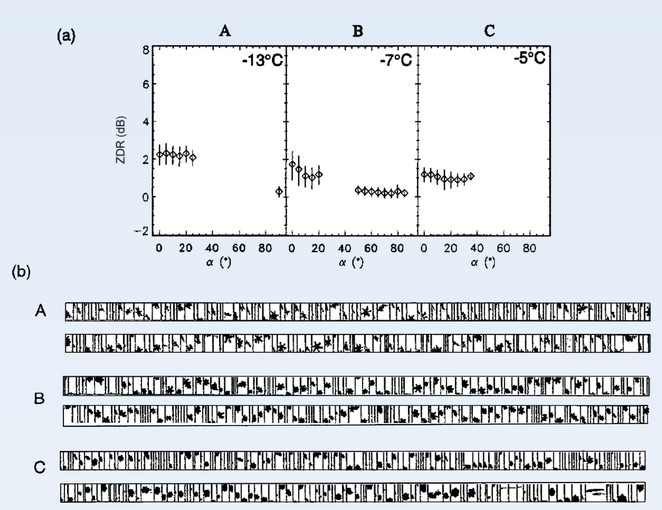


*Plate crystals without riming verified by in situ observations (Wolde and Vali, 2000)



Crystal habit from snowstorm observations (Magono and Lee, 1966)

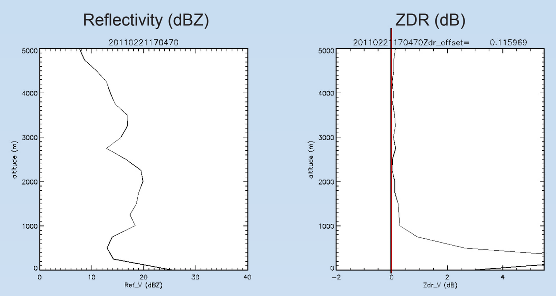


†Dendrite crystals with riming verified by in situ observations (Wolde and Vali, 2000)

* Fig. 1. (a) Variation of Z_{DR} and LDR_{HV} with radar beam incidence angle, α, in cloud regions of hexagonal plate (P1a) and/or stellar (P1d) crystals listed in lines 1–5 and 22–24 of Table 1. Means and standard deviations are indicated. Number of data points per α interval varies between a minimum of 20 and many thousands, depending on the flight pattern during data collection. (b) Sample 2D C images of the types of crystals included in this graph. The widths of the image strips is 800 μm.

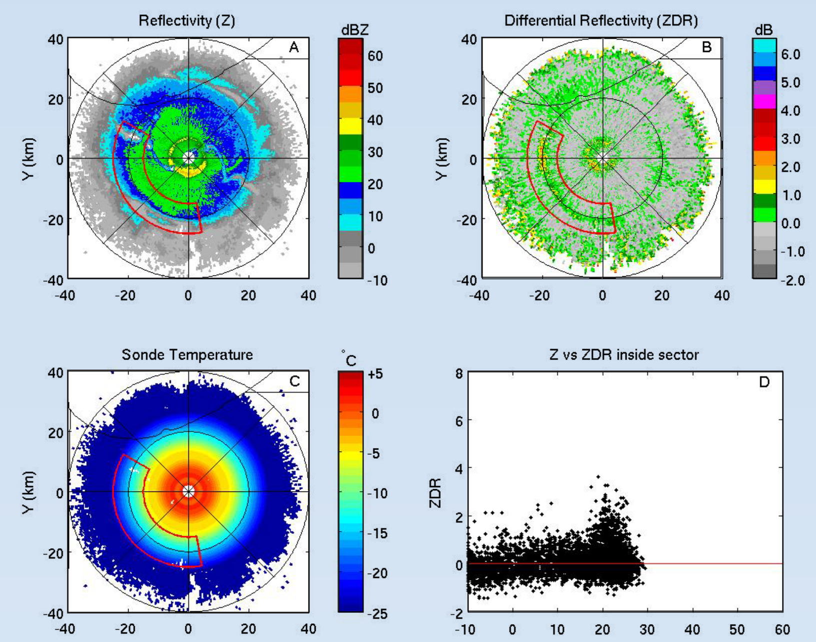
† Fig. 2. (a) Same as Fig. 1 except for dendrite crystals listed in lines 8, 9, and 25 of Table 1: A—lightly rimed, P1e; B—moderately rimed, R1d; and C—densely rimed crystals, R2d. (b) Samples of 2D-P images. The width of each strip represents 6.4 mm.

Polarimetric Radar Observations

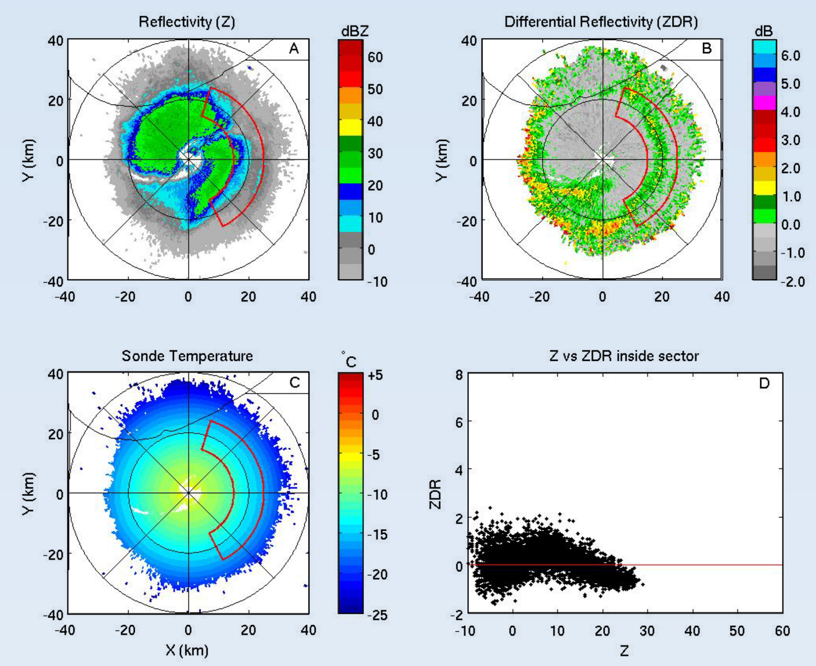


Vertical incidence 'bird bath' ZDR calibration check results for the Valparaiso University dual pol weather radar

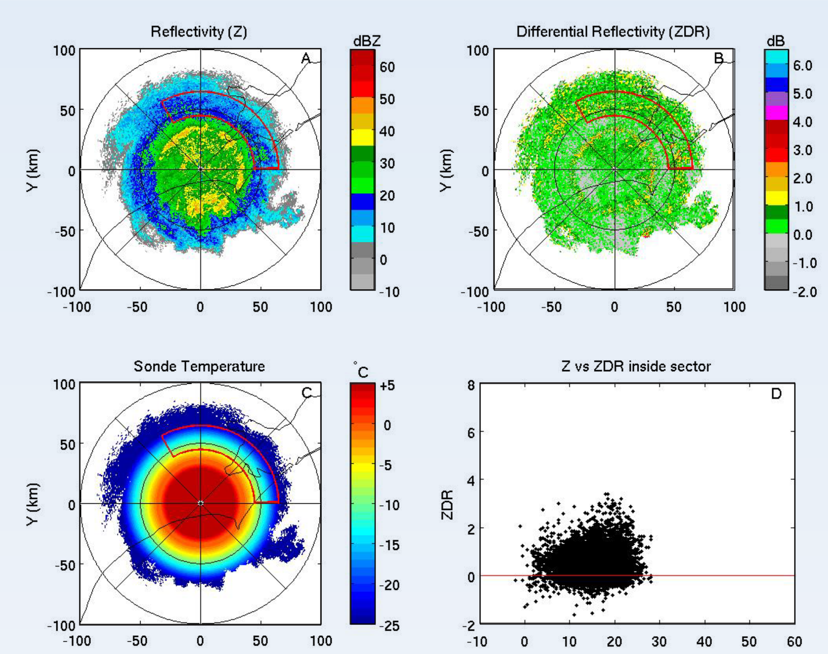
Category A



Valparaiso, IN – Dec. 8, 2009 – 2357 UTC – tilt 14 degrees

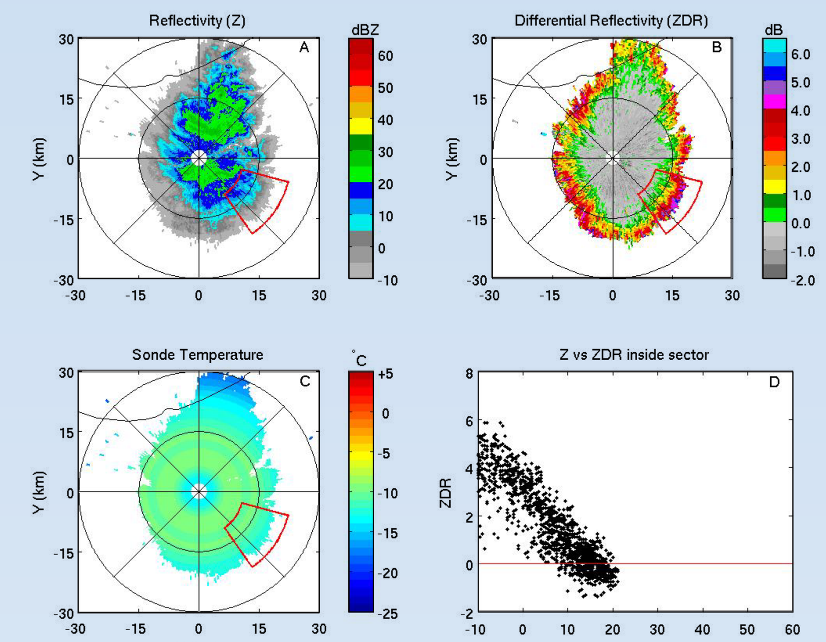


Valparaiso, IN – Feb. 24, 2010 – 1859 UTC – tilt 4.3 degrees

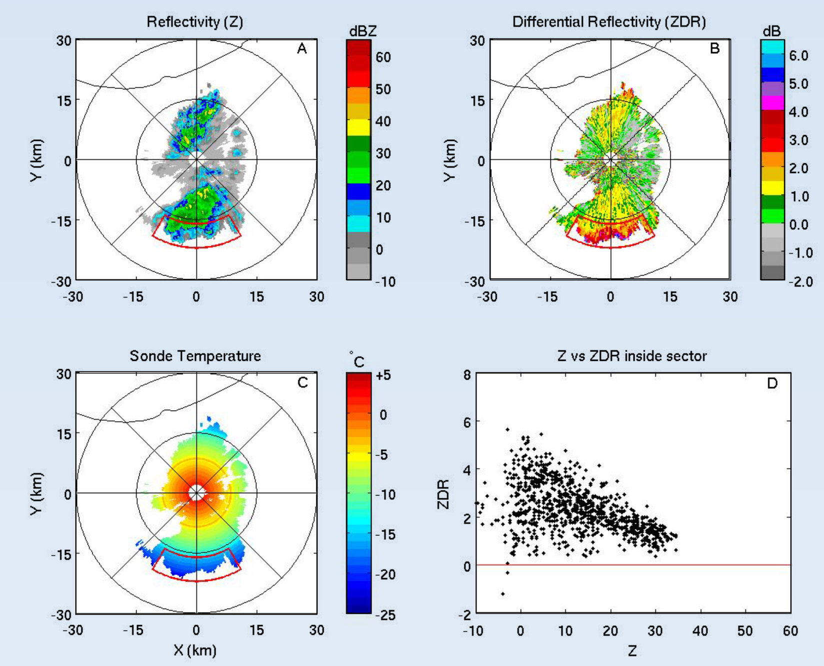


Morehead City, NC, NEXRAD – Hurricane Irene – Aug. 27, 2011 – 0043 UTC – tilt 8 degrees

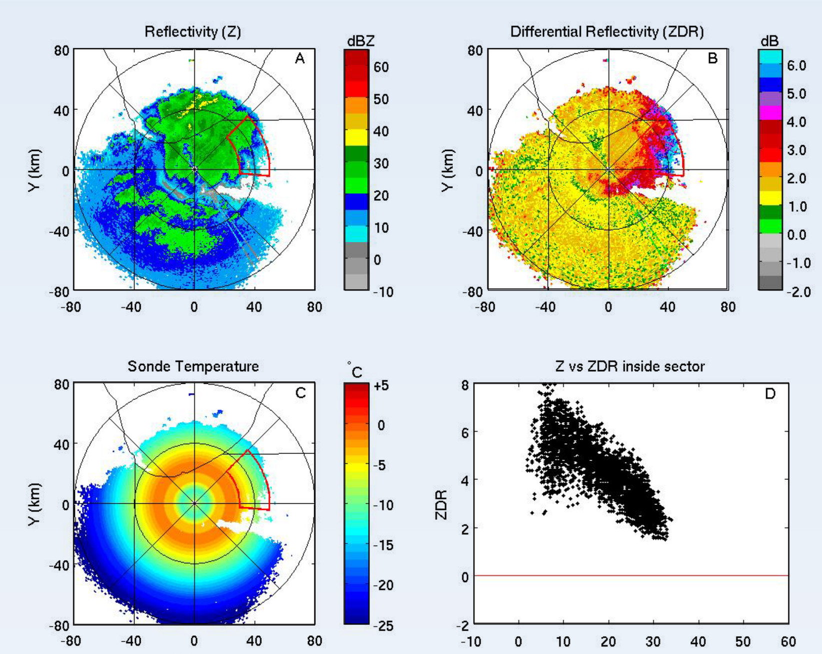
Category B



Valparaiso, IN – Jan 8, 2010 – 1625 UTC – tilt 4.3 degrees



Valparaiso, IN – Nov. 5, 2010 – 0514 UTC – tilt 10 degrees



Valparaiso, IN – Feb. 1, 2011 – 1912 UTC – tilt 4.3 degrees

Discussion

Plate Crystals

Ice-supersaturated conditions (Category B)

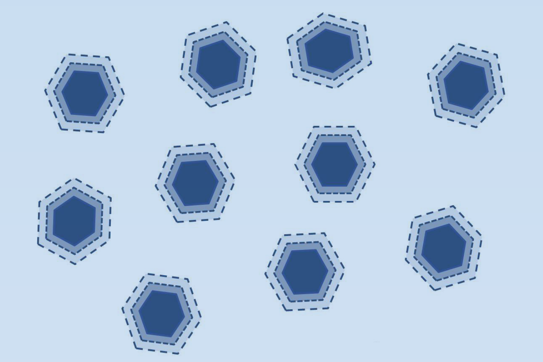
Location observed as patches and along edges

Weaker updraft

Small reflectivity (–10 to +10 dBZ)

Large +ZDR (+4 dB to +8 dB)

No icing hazard



Ice Supersaturation
Growing Hexagonal Plates

Dendrite Crystals

Water-saturated conditions (Category A)

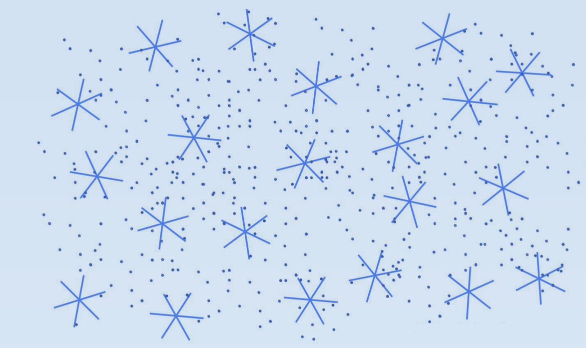
Defining signatures are +ZDR 'bright band' layers

Stronger updraft

Larger reflectivity (10 to 30 dBZ)

Weak +ZDR (+1 to +3 dB)

Icing hazard



Water Saturation
Growing Dendrites with Light Riming

Aggregates of Crystals

Ice- or water-saturated conditions

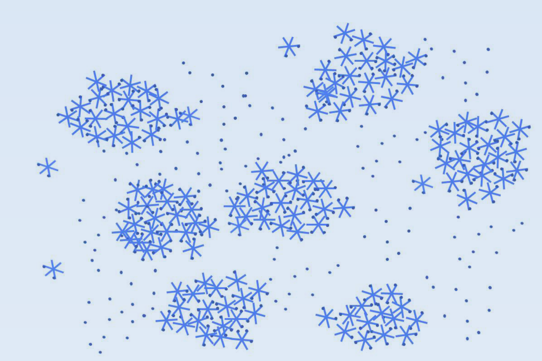
Not evident as a distinct feature

Strong updraft (if riming)

Largest reflectivity (20 to 30 dBZ)

Weakest +ZDR (0 to +2 dB)

Possible icing hazard



Water Saturation
Aggregation with Light Riming

Storm List

CATEGORY A	Z (dBZ)	+ZDR (dB) Anomaly
Herzegh and Conway (1986)		1.5 to 3
Bader et al. (1987)	10 to 20	1 to 3
Wolde and Vali (2000)	?	2
Hogan et al. (2002)	10 to 20	1 to 3
Andric et al. (2009)	10 to 24	1 to 3
Moissiev et al. (2009)	5 to 15	1 to 2.5
Kennedy and Rutledge (2011)		
Hurricane Irene*	13 to 23	2.2 to 3.4
CATEGORY B	**Z (dBZ)**	**+ZDR (dB) Anomaly**
Hogan et al. (1999)	–10 to +5	>4 dB
Wolde and Vali (2000)		
Jan. 8, 2010 – Indiana*	–5 to –13	6 to 7
Feb. 1, 2011 – Indiana*	4 to 8	7.5 to 7.9

* –Z and ZDR values reflect maximum range of sectors shown

Summary

- Distinct categorizations of dual pol radar signatures have been developed that can be related to microphysics (i.e., robust)
- Recent observations conform with those reported from past studies in the field and laboratory
- Insight gained; more evaluation across NEXRAD network planned
- Categorizations could be helpful, contributing information in an icing hazard algorithm
- Future work: need for simultaneous measurements of ice crystals and cloud water content at a sensitive level

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