New Concepts in Utilization of Polarimetric Weather Radars

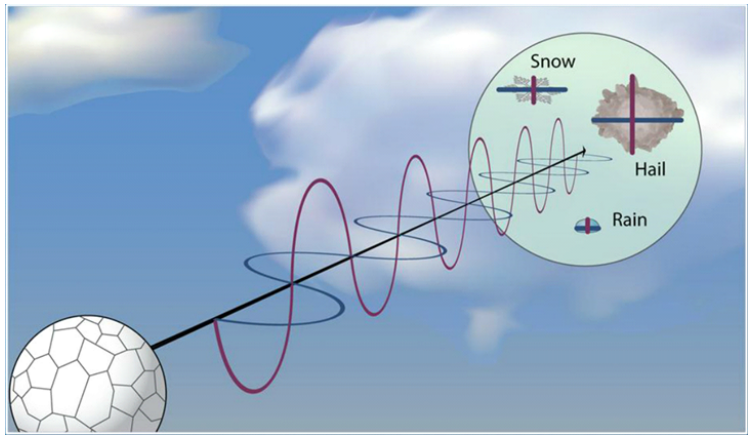
Alexander Ryzhkov (CIMMS)

February 25–27, 2015

National Weather Center

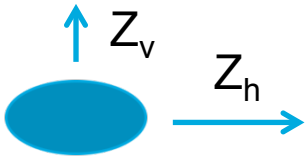
Norman, Oklahoma

Dual-polarization basics



Differential reflectivity $Z_{dr} = Z_h/Z_v$

Shape

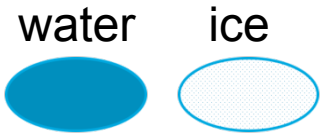


$$Z_{dr} > 1$$

Orientation

$$Z_{dr} = 1$$

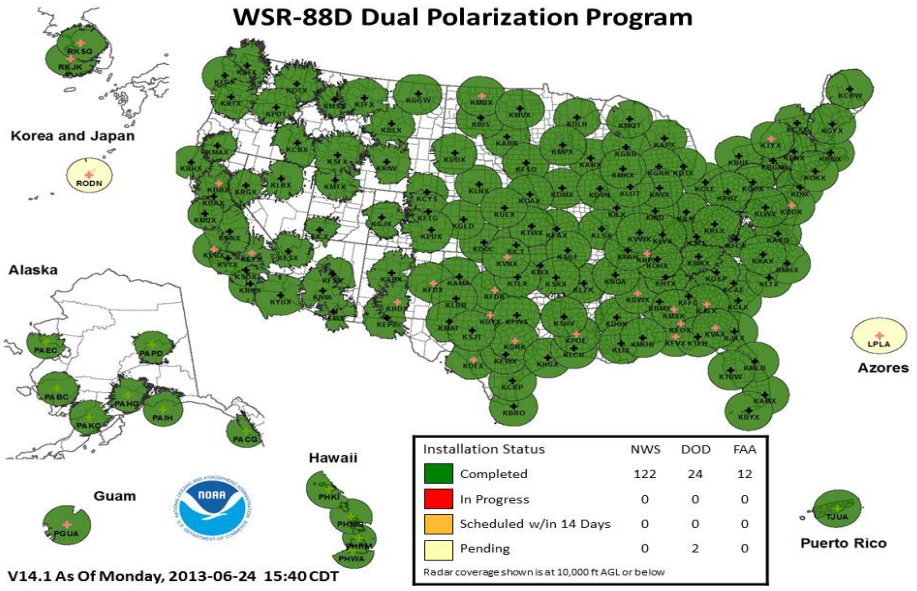
Phase composition



$$Z_{dr}^{(water)} > Z_{dr}^{(ice)}$$

Polarimetric radar variables are sensitive to hydrometeor (1) size, (2) shape, (3) orientation, (4) density, and (5) water content

Polarimetric upgrade of NEXRAD radars



160 research-quality dual-polarization operational radars

Role of NSSL in the NEXRAD polarimetric upgrade

- **Basic system design and participation in validation of radar variables and products**
- **Providing initial set of operational algorithms**
- **Developing necessary modifications of polarimetric radar algorithms and creating the new ones**

Classification of different types of radar echo

Hydrometeor Classification Algorithm (HCA)

Existing classes

1. GC/AP – ground clutter / AP
2. BS – biological scatterers
3. DS – dry aggregated snow
4. WS – wet snow
5. CR - crystals
6. GR – graupel
7. BD – “big drops”
8. RA – light and moderate rain
9. HR – heavy rain
10. HA – hail (possibly mixed with rain)

New classes to be added

1. FRZ – freezing rain
2. IP – ice pellets
3. SH - small hail (D < 2.5 cm)
4. LH – large hail (2.5 < D < 5.0 cm)
5. GH – giant hail (D > 5.0 cm)
6. TDS – tornado debris signature

Novel approaches

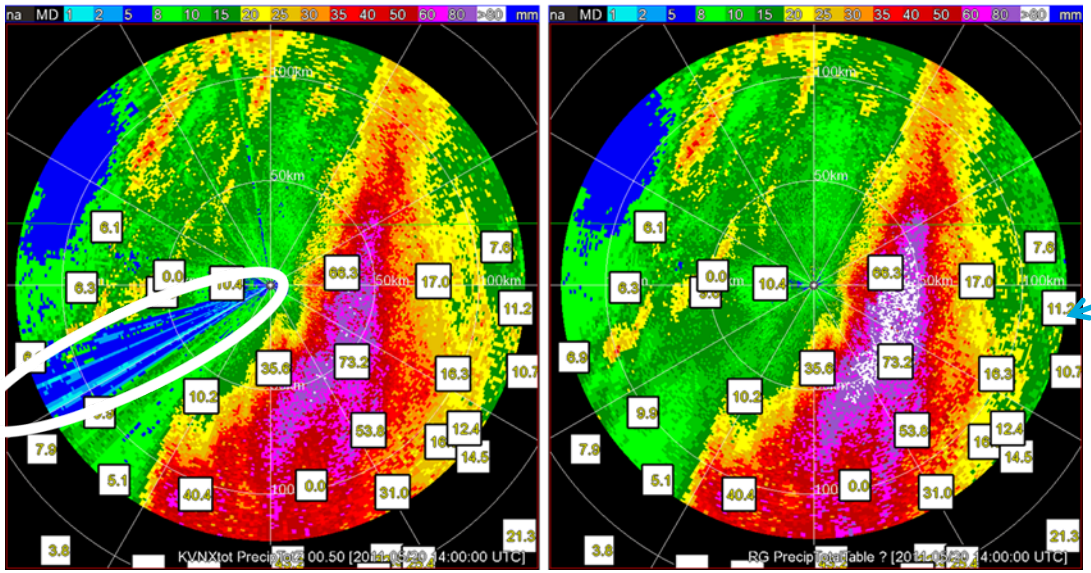
- Combining radar and NWP models
- Using new crowd-sourcing techniques (SHAVE and mPING) for HCA validation

Novel polarimetric techniques for rainfall estimation

Advantages of using specific attenuation A

- Lower sensitivity to the variability of drop size distributions
- Immunity to radar miscalibration, partial beam blockage, attenuation and impact of wet radome
- Ideal for networking and compositing of rainfall maps from different radars

R(Z) KVNX WSR-88D, 05/20/2011, 08 – 14 UTC R(A)



The bias due to beam blockage is eliminated in the R(A) rain total map

Networking polarimetric radars

- **Mosaic rainfall map exhibits discontinuity if the R(Z) relation is used**
- **The use of R(A) produces seamless mosaic rainfall map**

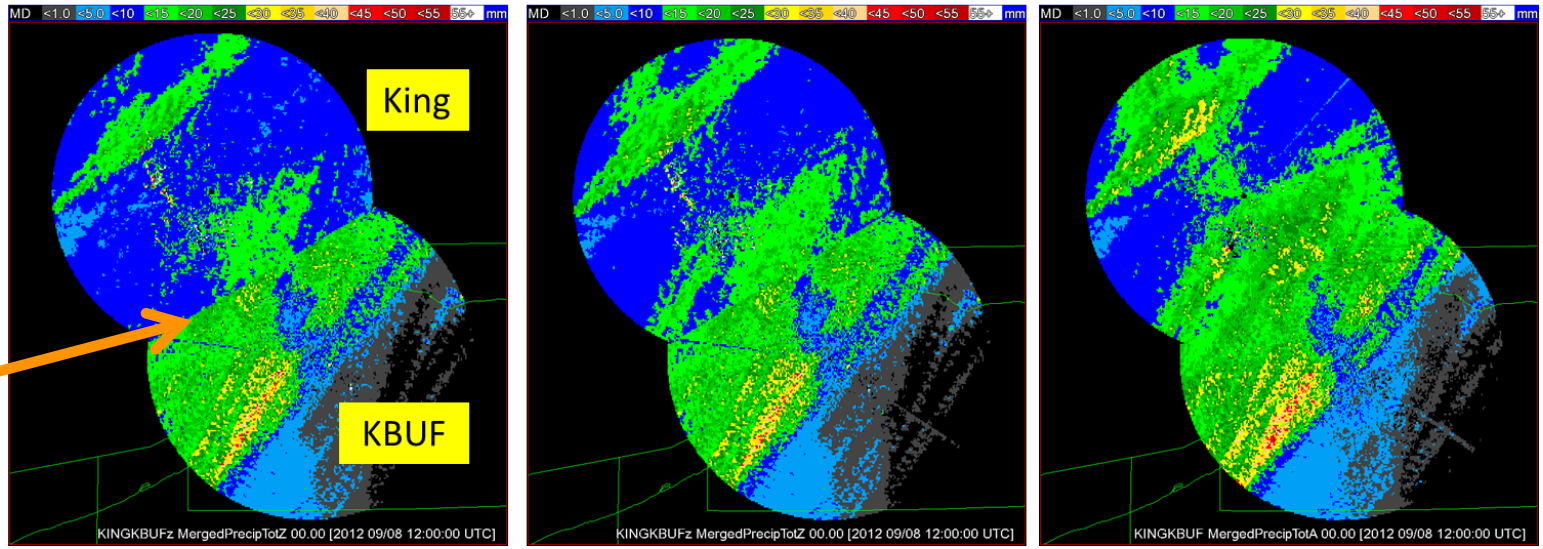
R(Z) before attenuation correction

R(Z) after attenuation correction

R(A)

6 hr rain total

Discontinuity



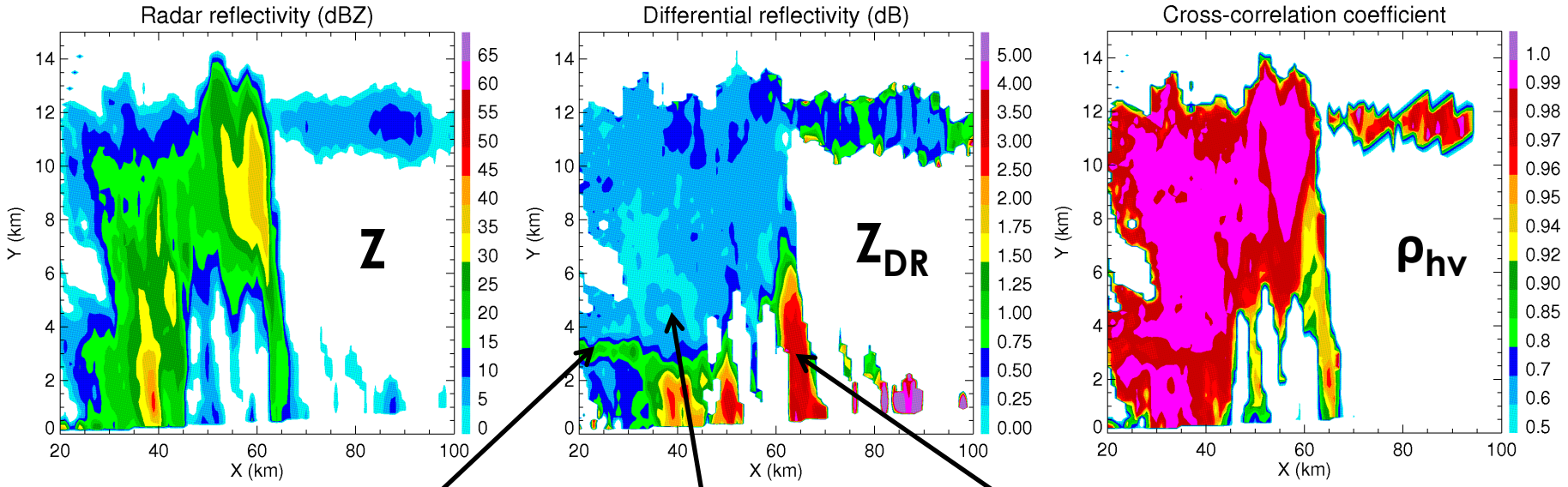
Identification of the polarimetric "fingerprints" of various microphysical processes using cloud models and radar observations

Microphysical processes

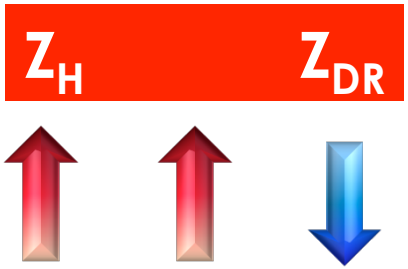
- **Size sorting**
- **Evaporation**
- **Coalescence**
- **Breakup**
- **Freezing / refreezing**
- **Depositional growth of ice**
- **Aggregation**
- **Riming**

- **A catalog of polarimetric fingerprints of individual microphysical processes has been created**
- **The fingerprints help forecasters to interpret radar data**
- **Cloud modelers can use fingerprints to improve microphysical parameterization and assimilation of radar data**
- **Polarimetric radar observation operator for cloud models has been developed**

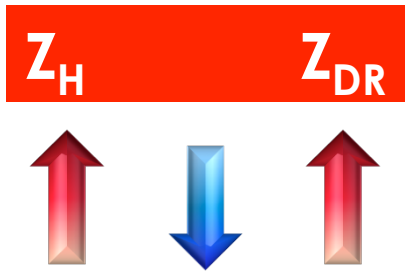
Example of polarimetric fingerprints



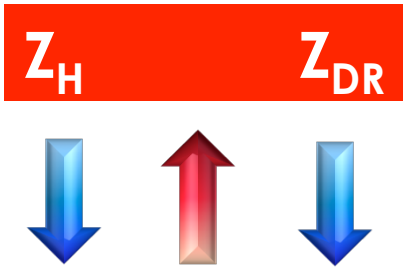
melting



riming



size sorting



Summary

Successes

- Polarimetric weather radar technology was brought to operations
- The algorithms for hydrometeor classification and rainfall estimation have been further refined using novel concepts
- The concept of “polarimetric fingerprints” has been introduced

Remaining challenges

- Utilization of dual-polarization radars for improvement of the performance of the NWP models is a next frontier of research