New Concepts in Utilization of Polarimetric Weather Radars

Alexander Ryzhkov (CIMMS)
February 25–27, 2015
National Weather Center
Norman, Oklahoma
Polarimetric radar variables are sensitive to hydrometeor (1) size, (2) shape, (3) orientation, (4) density, and (5) water content.

Differential reflectivity $Z_{dr} = \frac{Z_h}{Z_v}$

**Shape**

$Z_{dr} > 1$

**Orientation**

$Z_{dr} = 1$

**Phase composition**

$Z_{dr}^{(\text{water})} > Z_{dr}^{(\text{ice})}$
Polarimetric upgrade of NEXRAD 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

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.

Discontinuity

6 hr rain total
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

Radar reflectivity (dBZ)

Differential reflectivity (dB)

Cross-correlation coefficient

Z

Z_{DR}

Z_{H}

Z_{DR}

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