Polarimetric Radar Characteristics of Warm-Season Updrafts over KSC/CCAFS

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Dual-Polarization: Quick Refresher

Dual-pol radar: Receives horizontally and vertically oriented backscatter

Two methods:
- Alternating
  
  Expensive fast switch, longer acquisition times

- Simultaneous

  Simultaneous Transmit of Horizontal + Vertical Polarized Energy

  Some sensitivity loss

http://www.roc.noaa.gov/WSR88D/dualpol/
Dual-Polarization Products

Differential Reflectivity ($Z_{DR}$) [dB]

- Average horizontal vs. vertical dimensions of targets in a volume

<table>
<thead>
<tr>
<th>$&gt;0$ dB</th>
<th>$\sim0$ dB</th>
<th>$&lt;0$ dB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal</td>
<td>Spherical</td>
<td>Vertical</td>
</tr>
<tr>
<td>Rain 2mm, 3mm</td>
<td>Drizzle 1 mm</td>
<td>Vertical</td>
</tr>
<tr>
<td>Water-coated, smaller hail</td>
<td>Tumbling dry hail</td>
<td>Very large hail (Mie), some ice, some clutter</td>
</tr>
<tr>
<td>Biological</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Ice depends on wetness, density, preferred orientation; 
-2 to 4 dB

http://ga.water.usgs.gov/edu/raindropshape.html


AP Photo / Charlie Riede
Dual-Polarization Products

Correlation Coefficient (CC or $\rho_{HV}$) [unitless]

- Conforming behavior of targets from pulse to pulse in a volume

<table>
<thead>
<tr>
<th>Near 1.0</th>
<th>0.8 to 0.97</th>
<th>&lt;0.8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meteorological uniform</td>
<td>Meteorological non-uniform</td>
<td>Non-meteorological</td>
</tr>
<tr>
<td><img src="image1.png" alt="Clouds" /></td>
<td><img src="image2.png" alt="Snowflakes" /></td>
<td><img src="image3.png" alt="Clutter, Smoke, Tornado debris" /></td>
</tr>
</tbody>
</table>

- $>1.0$
  - Untrustworthy values in weak signal

http://www.wdtb.noaa.gov/courses/dualpol/Products/CC/player.html

ROSS TUCKERMAN/AFP/Getty Images
Dual-Polarization Products

**Differential Phase Shift ($\Phi_{DP}$) [degrees]**
- Horizontal vs. vertical radar wave phase shift
- Occurs rapidly in heavy rain.
  - Large droplets and high concentration
- Accumulates down radial.

**Specific Differential Phase Shift ($K_{DP}$) [degrees km$^{-1}$]**
- Range derivative of $\Phi_{DP}$

![Graph showing phase shift](image)

![Image of radar wave phase shift](image)

![Map showing radar wave phase shift](image)
One of these things is not like the others

1637 UTC, 21 June 2012

Z: Smoke

Z_{DR}: Highly variable

\rho_{HV}: Very low

Light Rain
Near 0, slightly positive
Very high
Updraft Melting Layer Signature; Harris (2011)

Proof of concept in preparation for KSC/CCAFS studies.
Melting Layer displacement in convection (Shusse et al. 2011).

Updraft Melting Layer Signature (UMLS) heights at KVNX and KICT vs. SPC wind reports.
Updraft Melting Layer Signature; Harris (2011)

No correlation found.
Many reasons why:
• Low density, perhaps unreliable max wind reports.
• Radar beam-spreading errors.
• Differing thermodynamic environment from case to case.
• Updraft and downdraft strengths controlled separately.

My turn: KMLB dual-pol upgrade, GR2Analyst version 1.92b
• Dual-pol products in cross sections.
• $K_{DP}$ available.
• High density wind mesonet.
Challenges

1. Physical/Environmental
2. Observation (Radar)
3. Visualization/Interrogation
Challenges

1. Physical/Environmental
   - FL warm-season convection vs. Harris (2011) severe Plains convection?
     Lower shear $\rightarrow$ sharper gradients of precip intensity
     Sporadic updrafts $\rightarrow$ chaotic storm structure
   - Maximum realistic lead time?
     From radar observation of new precip-laden updraft to downdraft ground winds $\rightarrow$ 10-20 minutes?
   - Locally modified thermodynamic environment?
     Successful radar-based nowcasting tool will likely need context of local thermal/moisture profile.
Challenges

2. Radar

- Low signal-to-noise ratio (SNR) (low reflectivity) $\rightarrow$ low $\rho_{HV}$
- Low SNR and $\rho_{HV} < 0.95$ $\rightarrow$ ZDR errors $>0.3$ dB, can appear noisy
2. Radar

- Non-uniform beam filling (sharp reflectivity gradients) $\Rightarrow$ low $\rho_{HV}$
- If $\rho_{HV} < 0.9$ $\Rightarrow$ $\Phi_{DP}$ noisy and unreliable $\Rightarrow$ $K_{DP}$ not computed
Challenges

2. Radar

- Beam broadening leads to apparent smearing of the melting layer.
  - ML typically a few hundred meters thick.
  - At 60 km range (KMLB to LC-39B), radar beam is 1 km thick.

- 1.0° x 0.25 km horizontal bins for tilts sampling KSC melting layer.
  - 1.0° is approx. 0.5 km near the Port, 1.25 km near northern KSC.
  - Fairly coarse resolution for small-scale FL convection.