Improvements to ground clutter mitigation for polarimetric Doppler weather radars

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NEXRAD Technical Advisory Committee

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What does Ground Clutter do?
- Obscures/biases meteorological-variable estimates

What does Ground Clutter look like?
- Reflectivity: wide range of values
- Doppler Velocity: near zero
- Spectrum Width: very narrow (< 0.5 m/s)

What can we do about Ground Clutter?
- Filter to mitigate obscuration/bias
- Misapplication of the filter affects data quality
  - Ground Clutter Filter may remove some weather signal
    - Challenge: zero-isodop weather (similar characteristics as ground clutter)
  - Tapered data window unnecessarily applied
snowing in Duluth, MN
snowing in Duluth, MN

WSR-88D
Forced Filtering
~50 km
simple radar return classification

- Ground Clutter
- Weather
- Mix Ground Clutter/Weather
- Clutter Dominates
- Weather Dominates
- No Weather/No Ground Clutter
can we tell where weather is?

- Dual polarization variables should help
  - **DP variables don’t discriminate well**
  - **spatial variability of DP variables do**

Best Discriminator: spatial standard deviation of $\phi_{DP}$

(source: Rico-Ramirez, 2008, IEEE TGRS)
identifying dominant weather

• Weather returns exhibit smooth $\phi_{DP}$ in range
  – Variability of $\phi_{DP}$: $\Delta \phi_{DP}(n) = \phi_{DP}(n+1) - \phi_{DP}(n)$
    • $n$ indexes range gates
  – Measured variability is due to spatial variability and statistical uncertainty (variance)
    • $(\Delta \phi_{DP})^2 = \sigma_{spatial}^2(\phi_{DP}) + \sigma_{estimate}^2(\phi_{DP})$
  – Spatial variability can be assessed by removing expected statistical uncertainty
    • Melnikov (2004) computed theoretical variance expression

• Dominant weather is identified as
  – Low spatial variability
    • Threshold on $\Delta \phi_{DP}$ based on look-up table
  – SNR > 20 dB and $\rho_{hv} \geq 0.99$
**WET** and **CLEAN-AP** work together to provide an improved ground clutter mitigation solution.
snow again, Duluth, MN (v)

WET/CLEAN-AP
snow again, Duluth, MN ($\phi_{DP}$)
snow again, Duluth, MN (Z_{DR})

WET/CLEAN-AP
snow again, Duluth, MN ($\rho_{hv}$)

WET/CLEAN-AP
ground clutter mitigation

- **CLEAN-AP**
- **Weather Environment Threshold (WET)**
- **No Weather/No Ground Clutter**

Mix Ground Clutter/Weather
Back Up Slides Analysis
Test Cases, Unfiltered Range Bins
clutter affects DP variables more!

• Friedrich et al., JTECH, 26, 2009
  – Combine
    • Real weather level-I (I&Q voltages)
    • Ground Clutter level-I (I&Q voltages)
    • Using different mixing ratios

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Error of Estimate</th>
<th>CSR (dB)</th>
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<tbody>
<tr>
<td>$Z_n$</td>
<td>1.7 dB</td>
<td>-1</td>
</tr>
<tr>
<td>$\Phi_{DP}$</td>
<td>3°</td>
<td>-6</td>
</tr>
<tr>
<td>$Z_{DR}$</td>
<td>0.2 dB</td>
<td>-9</td>
</tr>
<tr>
<td>$\rho_{hv}$</td>
<td>0.02</td>
<td>-13</td>
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