A Two-Dimensional Velocity Dealiasing Algorithm for the WSR-88D

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Outline

• WSR-88D Velocity Dealiasing Algorithms – Strengths/Weaknesses
  – Baseline Velocity Dealiasing Algorithm (VDA)
  – Baseline Multiple PRF Dealiasing Algorithm (MPDA)
  – New 2-Dimensional Dealiasing Algorithm (VDEAL)

• ROC evaluation results & hurricane examples

• NSSL VCP 31 results & clear-air example

• Field test summer & fall 2011
Baseline Velocity Dealiasing Algorithm (VDA)

**Strengths**
- Fast
- Requires minimal amount of computer resources
- Works well in most situations
- Works with all Volume Coverage Patterns (VCPs) except VCP 121

**Weaknesses**
- Does not handle strong shears well
- Errors can be propagated azimuthally and radially
- Fails in moving clutter environments
- Fails in regions with weak signal and noisy velocities
- Fails in long-pulse clear air velocity data (VCP 31)
Multiple PRF Dealiasing Algorithm (MPDA) with VCP 121

Strengths

• Provides robust velocity dealiasing where more than one velocity estimate is available
• Provides nearly complete velocity coverage out to 125 n mi (230 km)
• Removes range folding at the start of second trip

Weaknesses

• Not well suited for fast moving, rapidly evolving storm systems
• Requires multiple scans of velocity data at same elevation angle
  – Limits number of unique elevation scans to 9
  – Lengthens volume scan time
• May have errors where only one velocity estimate is available, esp. at long range
## 2-Dimensional Velocity Dealiasing Algorithm (VDEAL)

### Strengths
- Provides robust velocity dealiasing solutions for all VCPs except VCP 121 which uses MPDA
- Works well at all ranges
- Works much better in long-pulse clear air (VCP 31) than Baseline VDA

### Weaknesses
- Isolated regions may not be dealiased correctly if different from global environmental wind solution
- Requires substantial computer resources
- Does not work with sectorized PRFs
ROC Data Analyzed

• 15 precipitation events
  – 3 hurricanes
  – 5 squall lines
  – 7 circulations in ground clutter

• 520 velocity products
  – 0.5 deg elevation angle
  – 1 deg azimuthal resolution

• VCPs 11, 12, 21, & 212
Scoring Methodology Used by NSSL and ROC

Each velocity product image starts with a score of 100 from which points are subtracted as follows:

<table>
<thead>
<tr>
<th>Description of Error</th>
<th>Penalty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single gate or 2 adjacent gates</td>
<td>–1</td>
</tr>
<tr>
<td>Small radial spike (&lt;3 km in length)</td>
<td>–2</td>
</tr>
<tr>
<td>Very small patch</td>
<td>–2 to –3</td>
</tr>
<tr>
<td>Small patch</td>
<td>–4 to –8</td>
</tr>
<tr>
<td>Large patch</td>
<td>–8 to –12</td>
</tr>
<tr>
<td>Swath of ~20°</td>
<td>–12 to –16</td>
</tr>
<tr>
<td>Swath of ~40°</td>
<td>–26 to –30</td>
</tr>
<tr>
<td>Swath of ~60°</td>
<td>–32 to –38</td>
</tr>
<tr>
<td>Swath of ~90° or larger</td>
<td>–40 to –50</td>
</tr>
</tbody>
</table>
**ROC Results**

**Number of Volume Scans by Category**

- **Hurricanes**
  - 133 cases
- **Squall Lines**
  - 186 cases
- **Circulations**
  - 201 cases

**Raw Score**

- **VDA**
  - Hurricanes: 93
  - Squall lines: 98
  - Circulations: 96
- **VDEAL**
  - Hurricanes: 95
  - Squall lines: 100
  - Circulations: 97

2D Dealiasing IHC 2011
ROC Results (Cont’d)

Hurricane Analysis

- **Hurricane Rita (KLCH)**
  - 24 September 2005
  - 62 Volumes
  - VCP 21
- **Hurricane Gustav (KLIX)**
  - 1 September 2008
  - 39 Volumes
  - VCP 212
- **Hurricane Ike (KHGX)**
  - 13 September 2008
  - 100 Volumes
  - VCP 212
KLIX Hurricane Gustav
1 Sep 2008, 13:17Z, VCP 212

Baseline VDA

2-D VDEAL
KLIX Hurricane Gustav
1 Sep 2008, 15:16Z, VCP 212

Baseline VDA

2-D VDEAL
KLIX Hurricane Gustav
1 Sep 2008, 16:47Z, VCP 212

Baseline VDA  2-D VDEAL
KHGX Hurricane Ike
13 Sep 2008, 06:12Z, VCP 212

Baseline VDA

2-D VDEAL
KHGX Hurricane Ike
13 Sep 2008, 06:21Z, VCP 212

Baseline VDA  2-D VDEAL
KHGX Hurricane Ike
13 Sep 2008, 06:45Z, VCP 212

Baseline VDA

2-D VDEAL
Outflow Boundary, Norman, OK

Baseline VDA

2-D VDEAL
NSSL Results for VCP 31

KDMX, December 3, 2008, VCP 31
Light Precipitation w/Frontal Boundary

- Baseline VDA
- Old VDEAL
- New VDEAL

Raw Score

1 deg azm

1/2 deg azm
KDMX, 3 Dec ‘08, 13:02Z, VCP 31, 1.5° Elev
Frontal Boundary South of Radar

Reflectivity image

Velocity image from Baseline VDA

Velocity image from early version 2-D VDEAL

Velocity image from new version 2-D VDEAL
Field Test of VDEAL

- Field test to run 1 June to 1 December, 2011
  - Coincide with hurricane season
  - Toggle will allow sites to switch between baseline VDA and new 2-D VDEAL
  - Looking for participation from 8+ sites
    - 4+ coastal
    - 2 mountainous
    - 2 other interior sites
Goals of VDEAL Field Test

• Obtain field experience with VDEAL at new sites under a broad range of meteorological conditions
• Obtain feedback from operational users
• Determine if VDEAL can replace the VDA for most VCPs or simply be an option

Exceptions
– VCP 121 will continue to use the MPDA
– PRF sectoring will invoke VDA
Tentative Field Test Schedule

• December 2010/January 2011 obtain approval to conduct field test

• February to May 2011
  – Assemble test team
  – Formulate test plans/evaluation criteria
  – Solicit participation from field sites

• June 1 to December 1, 2011 – conduct field test and begin data evaluation

• December 2011 to March 2012 – conclude data evaluation, write final report, make recommendation

• If successful, determine when to deploy
Questions

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Supplemental Slides
Baseline Velocity Dealiasing Algorithm (VDA)

- Applies algorithm sequentially on a radial by radial basis
  - Saves a copy of last good dealiased radial
- Uses Environmental Wind Table to provide initial value for dealiasing
- Dealiasing proceeds along a radial using nearby velocity bins or an average of nearby bins that have already bin dealiased
- Checks for and attempts to correct unrealistic radial or azimuthal shears
- Assigns original velocity values to unresolved velocity bins
Baseline Multiple PRF Dealiasing Algorithm (MPDA)

- Algorithm sequentially acquires up to 3 velocity scans each with a different Nyquist velocity at the same elevation angle
- Uses environmental wind data to help with dealiasing
- First dealiases 3 velocity values, where available, for the same point in space to find a solution
- If no solution found from previous step, dealiases pairs of velocities from the 3 estimates or if there are only 2 velocities are available
- If no solution found from the previous step, dealiases velocity data where only 1 value is available
- Finally, If no acceptable solution found, puts in the best fitting velocity from any velocity field into the dealiased velocity field
- Checks between steps for unrealistic shears and isolated bins
- Values put in the output velocity field provide reference values for downstream dealiasing
2-Dimensional Velocity Dealiasing Algorithm (VDEAL)

- Uses least-squares approach to dealias velocity discontinuities simultaneously on a full velocity field
- Develops its own wind profile
- Develops a coarse (sub-sampled) global solution and then resolves discontinuities in smaller regions
- Assigns more weight to velocity differences near $\pm 2V_N$
- Assigns more weight to velocity differences in regions with low spectrum width than those with high spectrum width
- Temporarily removes velocity values from side-lobe contamination during dealiasing
- Dealisases separately regions connected by a narrow bridge of noisy data
Bulk Statistics VDA vs VDEAL from Applications Branch Study

2D VDA v. Current VDA Comparison of Volumes With and Without Dealiasing Errors

- VDA, 252
- VDA, 268
- 2D VDA, 449
- 2D VDA, 71

- Volumes With Errors
- Volumes Without Errors
## Comparison of NSSL and ROC Analyses

<table>
<thead>
<tr>
<th>NSSL</th>
<th>ROC</th>
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<tr>
<td>• All elevation angles</td>
<td>• 0.5 deg elevation angle</td>
</tr>
<tr>
<td>• Examined both 1 deg and $\frac{1}{2}$ deg resolution velocity</td>
<td>• Examined only 1 deg resolution velocity products</td>
</tr>
<tr>
<td>products</td>
<td>• Evaluated 15 precipitation events</td>
</tr>
<tr>
<td>• Evaluated 1 clear-air; 5 precipitation events</td>
<td>• VCPs 11, 12, 21, &amp; 212</td>
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<tr>
<td>– VCPs 12, 31 &amp; 212</td>
<td>– Hurricanes, squall lines, &amp; tornadic storms</td>
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<tr>
<td>– Hurricane, squall line, storms, &amp; frontal boundaries</td>
<td>– VCPs 11, 12, 21, &amp; 212</td>
</tr>
<tr>
<td>– $\sim$920 1 deg velocity products</td>
<td>– Hurricanes, squall lines, &amp; tornadic storms</td>
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<td>– $\sim$200 $\frac{1}{2}$ deg velocity products</td>
<td>– 520 velocity products</td>
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