828 A Novel Approach To Reducing Dealiasing Errors For Staggered Pulse Repetition Time Waveforms

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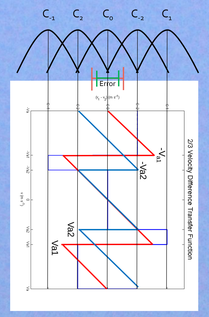
Problem

The Radar Operations Center is currently evaluating the operational use of staggered PRT to mitigate range-velocity at the intermediate elevations as a replacement to the batch mode. During the evaluation of the staggered PRT velocity, so-called "catastrophic" errors (i.e., failure of the velocity dealiasing transfer function) were observed under different types of radar echo conditions typically having low signal strength and/or high spectrum width. For example (see panel, far right):

1. Clear air returns near the radar,
2. Weak echo returns on the fringes of stratiform events,
3. Strong echoes in squall lines, and
4. Storm top divergence near the end of the unambiguous range of the shorter PRT.

2/3 staggered PRT Ratio Errors



The velocity difference transfer function (VDTF) using a 2/3 ratio has 5 unique values [C_{-1}, C_2, C_0, C_{-2}, C_1] spaced $v_a/3$ apart.
(see: Torres, S., Y. Dubel, and D. Zrnić, 2004: Design, Implementation, and Demonstration of a Staggered PRT Algorithm for the WSR-88D. *J. Atmos. Oceanic Technol.*, **21**,1389 –1399)

The difference between the velocity estimates, $v_1 - v_2$, from two interlaced pulses at different pulse repetition times (PRTs) should match the VDTF; however, errors in the velocity estimates (assumed Gaussian) create errors in the dealiased velocity.

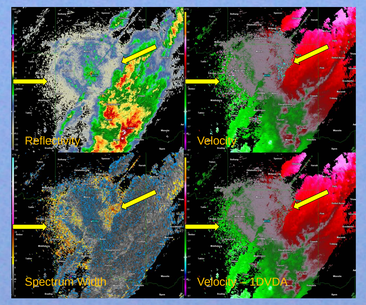
Mitigating "Catastrophic' Errors: 1DVDA

- Dealias v_1 using VDTF and velocity difference ($v_1 - v_2$) (closest fit).
- Monitor the closeness of fit between the VDTF and ($v_1 - v_2$):
  - Error less than (v_a/3)/3. (Note: 1/3 C-spacing of VDTF)
  - Flag as "Highly Confident" if 5 range gates are less than error threshold.
- Compare characteristics of dealiased velocity with v_1 and v_2:
  - Circular difference (i.e., minimum distance between velocity estimates when aliased on the Nyquist velocity co-interval) in range of both dealiased velocity and v_1 should agree.
  - Avoid large range-shears in v_1 or v_2.
  - Flag as "Moderately Confident" if 5 range gates compare well.
- Combine "Highly Confident" and "Moderately Confident" flags:
  - Signal-to-noise ratio is above noise level.
  - Flag as "Confident" and do not change.
- All gates that are not "Confident" are compared to closest "Confident" gates:
  - Gates at beginning/end of radial:
    - Compared to "Confident" regions within 10 km.
    - Reduce circular difference between dealiased velocity and reference velocity.
    - Correct by v_a (Note: For 2/3 ratio, only one of two values can be correct, v_1 or ($v_1 \pm v_a$).
  - Gates between "Confident" regions are compared to an interpolated value between "Confident" regions.
    - Reduce circular difference between dealiased velocity and reference velocity.
    - Correct by v_a.

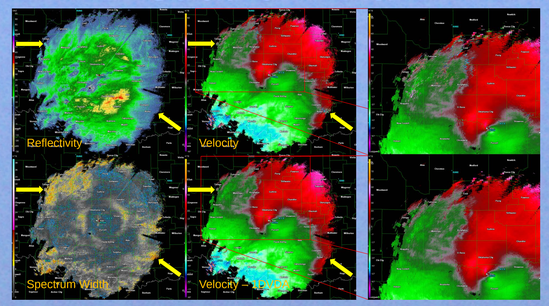
Real Weather Examples

Figures show reflectivity (upper left), velocity (upper right), spectrum width (bottom left), and velocity with 1DVDA (bottom right) PPI displays of the SPRT algorithm (2:3 ratio). The velocity dealiasing "catastrophic" errors occur when velocity estimate variance is too large which coincides with weak weather and/or wide spectrum width (e.g., yellow arrows in figures). Four cases are highlighted: 1. Clear Air, 2. Stratiform Rain, 3. Squall Line, and 4. Storm Top Divergence.

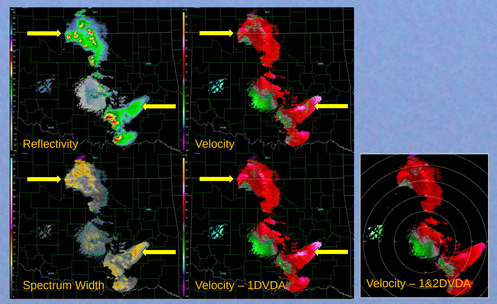
1. Clear Air



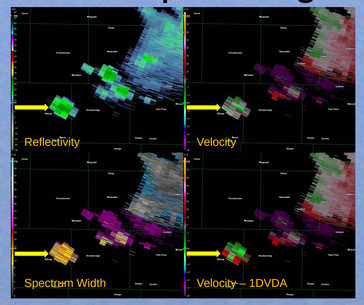
2. Stratiform Rain



3. Squall Line



4. Storm Top Divergence



Summary

Implementation, integration, and testing of staggered PRT waveforms for improved range and velocity ambiguity mitigation is well underway for the NEXRAD network. The operational use of staggered PRT waveform is expected to replace the batch waveform used at intermediate levels of NEXRAD volume coverage patterns in a future software build. Early analysis of staggered PRT output has shown improvement in the quality of reflectivity, spectrum width, differential reflectivity, cross-correlation coefficient, and differential phase over batch output. The inclusion of 1DVDA in the processing will help mitigate dealiasing errors in velocity at the signal processing level.