Update of Wind Turbine Clutter Study at the University of Oklahoma

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Outline

• KDDC Level-I Experiment, June 2006

• Simple 3D Interpolation Results

• Doppler Spectra Examples from Wind Turbine Clutter (WTC)

• KTFX Level-I Experiment, November 2006

• Examples of Multi-Trip and Three-Body Scatter from WTC Verified by Doppler Spectra
Gray County Wind Farm

Near KDDC

- Located 25 miles SW of Dodge City, Kansas
- 170 towers
- Height of Tower: 217 feet (66m)
- Length of Blades: 77 feet (23.5m)
- RPM: 28.5
- Tip Velocity: 70.14 ms\(^{-1}\)
Level-II Radar Loop

Dodge City, Kansas (KDDC), June 17, 2006

QuickTime™ and a Cinepak decompressor are needed to see this picture.
Given Level-I data, it is possible to combine the Wx and WTC signals.
KDDC VCP 21 Scanning Data

Wx/WTC Interaction
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Level-II Interpolation Method

- Global Interpolation using a Radial Basis Function, weights are determined by the distance between the points
- Use the “multiquadric” method developed by Roland Hardy, 1971
- Approximate desired function $F$ at location $x$ by a function $S$

$$S(x) = \sum_{i=1}^{N} a_i \Phi(||x - x_i||)$$

$$\Phi(d) = (d^2 + c^2)^{\frac{1}{2}}$$
Level-II Interpolation Results

KDDC, 3D Interpolation Reflectivity
Level-II Interpolation Results

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The Doppler spectrum is a power-weighted distribution of radial velocities within the resolution volume.

**Examples of unique velocity distributions:**
- Tornados
- Ground Clutter
- Sea Clutter
- Birds
- Wind Turbine Clutter (WTC)

Spectral Processing Possible With ORDA
KDDC Spotlight

Single Isolated Turbine

[Image of a graph and a time spectrum with labeled areas for Tower and WTC]
KDDC VCP 21 Scanning Data

WTC & Wx: Range/Azimuth Continuity in Doppler Spectra
• KDDC Level-I Experiment, June 2006

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• KTFX Level-I Experiment, November 2006

• Examples of Multi-Trip and Three-Body Scatter from WTC Verified by Doppler Spectra
• Located 6 km West of Great Falls, MT
• 6 towers
• Height of Tower: 262.4 feet (80m)
• Length of Blades: 126 feet (38.5m)
• RPM: Variable, 11-20.4 rpm
• Max Tip Velocity: 82.25 ms

Great Falls, Montana
Near KTFX
Wind Farm KTFX
KTFX VCP 21 Scanning Data

WTC During Clear-Air
Level-II Interpolation Results

*KTFX, 2D Interpolation of Reflectivity (Clear-Air)*
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Interesting Scattering Effects

KTFX, Multi-Trip, and Multi-Turbine Interaction

"Three-Body Scatter Spike"

4-Way Trip

Primary

Multi-Trip Echoes
Summary and Future Work

- Explored WTC characteristics (Doppler spectra and moments) from Dodge City and Great Falls WSR-88Ds
- Developed simple interpolation technique (loss in resolution)
- Investigated existence & characteristics of multi-trip and three-body scatter for Great Falls case
- Future work will include interpolation scheme based on three-dimensional continuity of Doppler spectra

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