Update of Wind Turbine Clutter Study at the University of Oklahoma

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Atmospheric Radar Research Center

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)

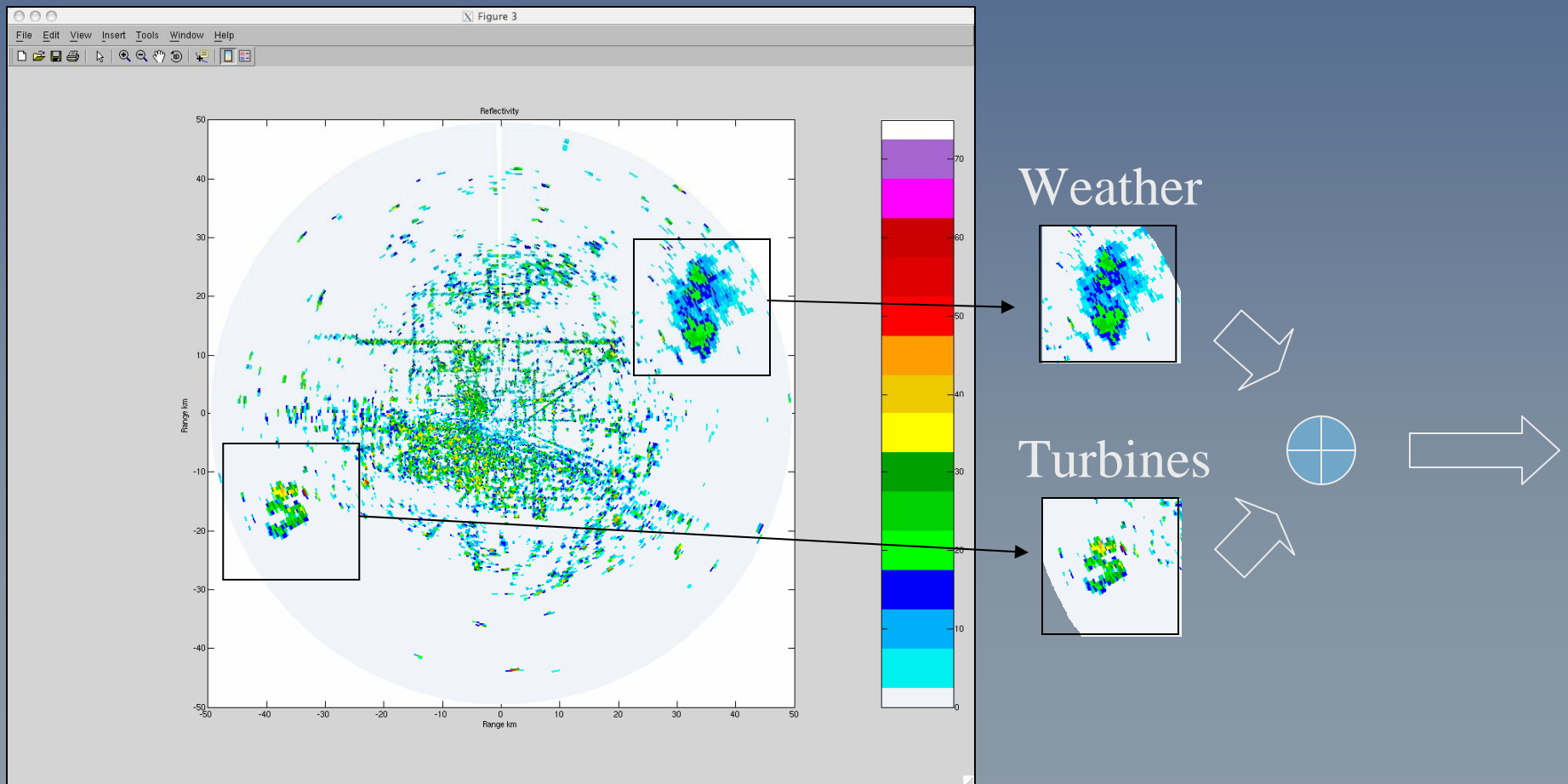- RPM: 28.5

- Tip Velocity: 70.14 ms^{-1}

Level-II Radar Loop
Dodge City, Kansas (KDDC), June 17, 2006

QuickTime™ and a
Cinepak decompressor
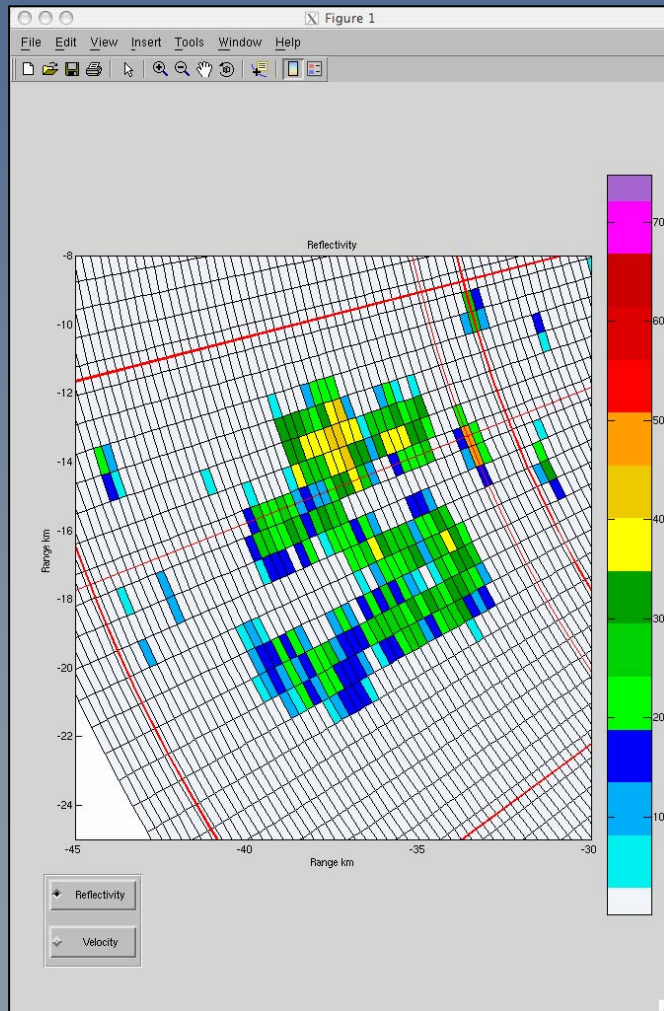are needed to see this picture.

KDDC VCP 21 Scanning Data
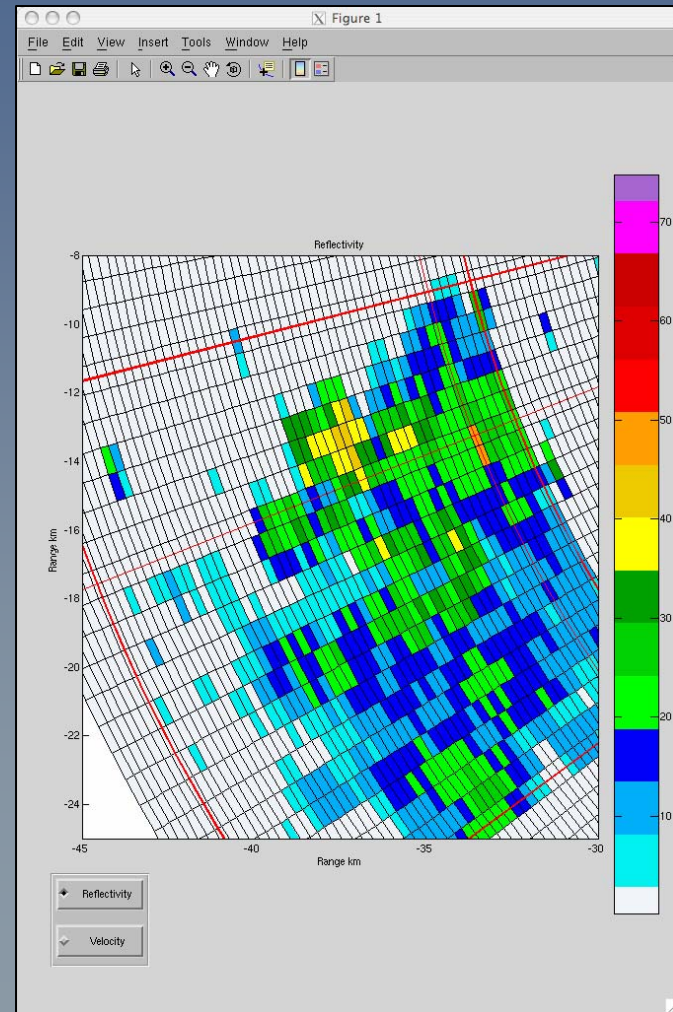## *Mixed Wx and WTC, March 31, 2006*

Given Level-I data, it is possible combine the Wx and WTC signals

KDDC VCP 21 Scanning Data
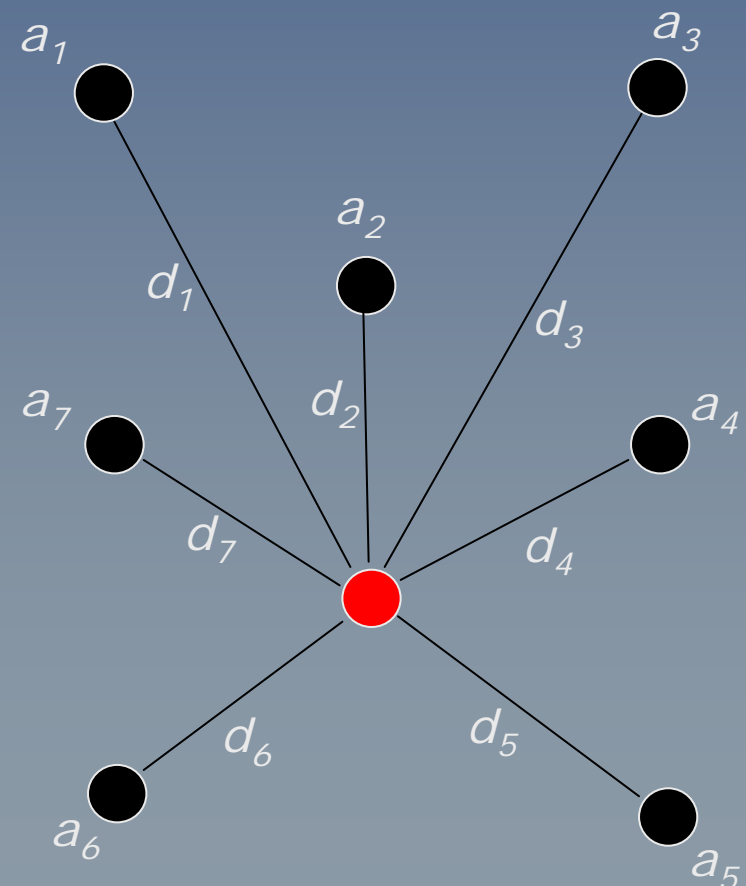## *Wx/WTC Interaction*

WTC Only

WTC and Wx

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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

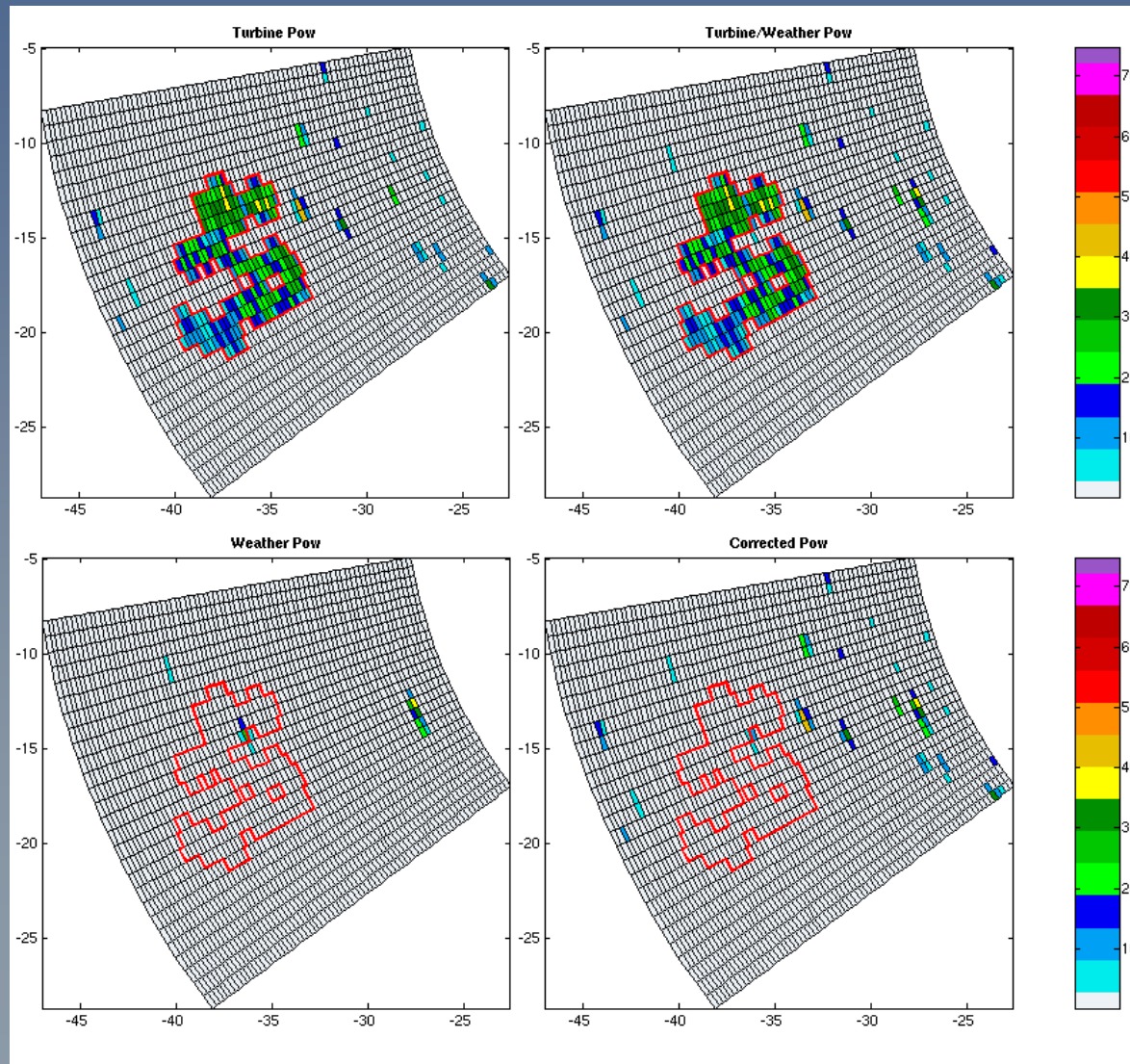- Approximate desired function F at location x by a function S

$$S(x) = \sum_{i=1}^{N} a_i \Phi(\|x - x_i\|)$$
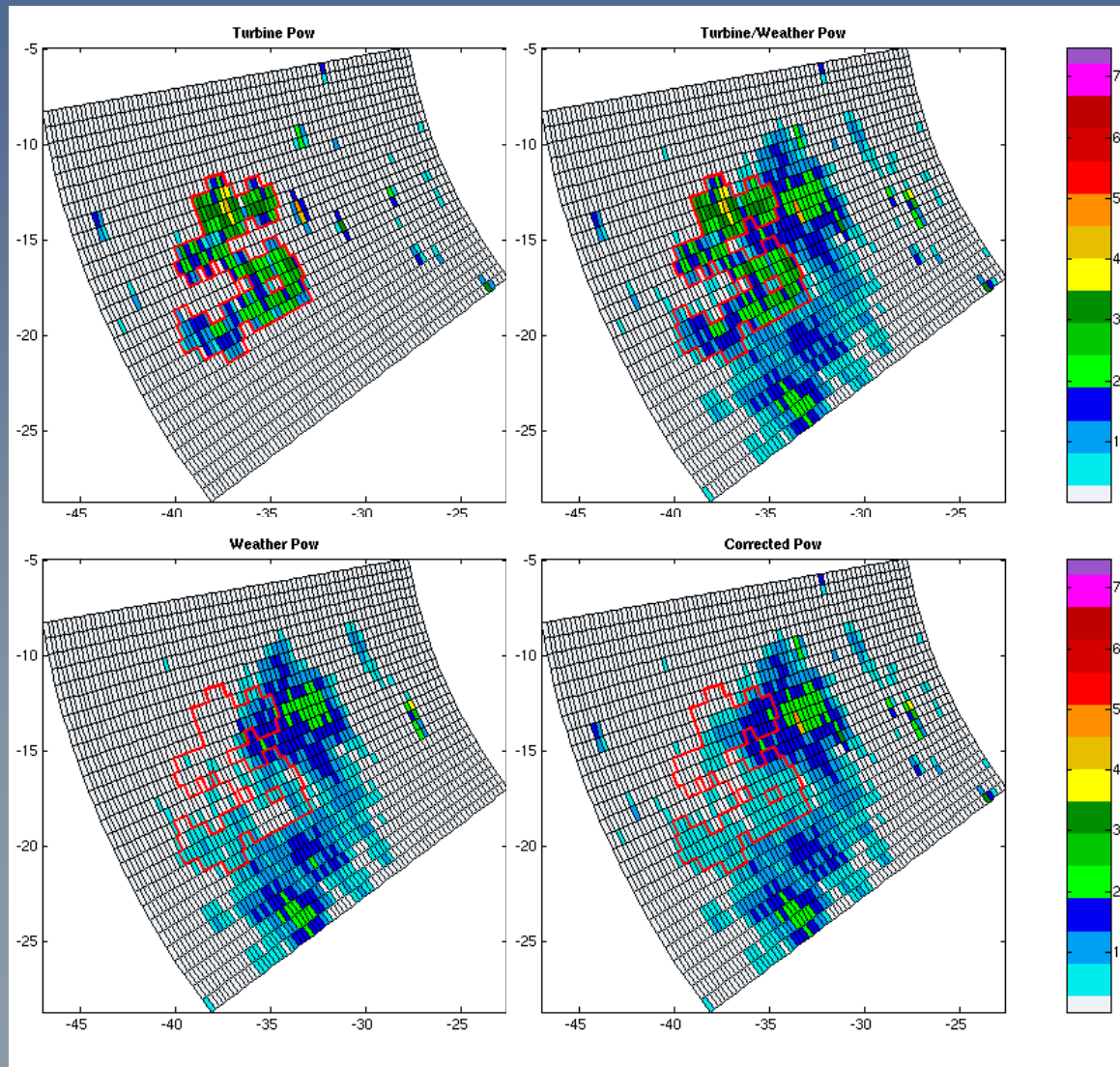
$$\Phi(d) = (d^2 + c^2)^{\frac{1}{2}}$$

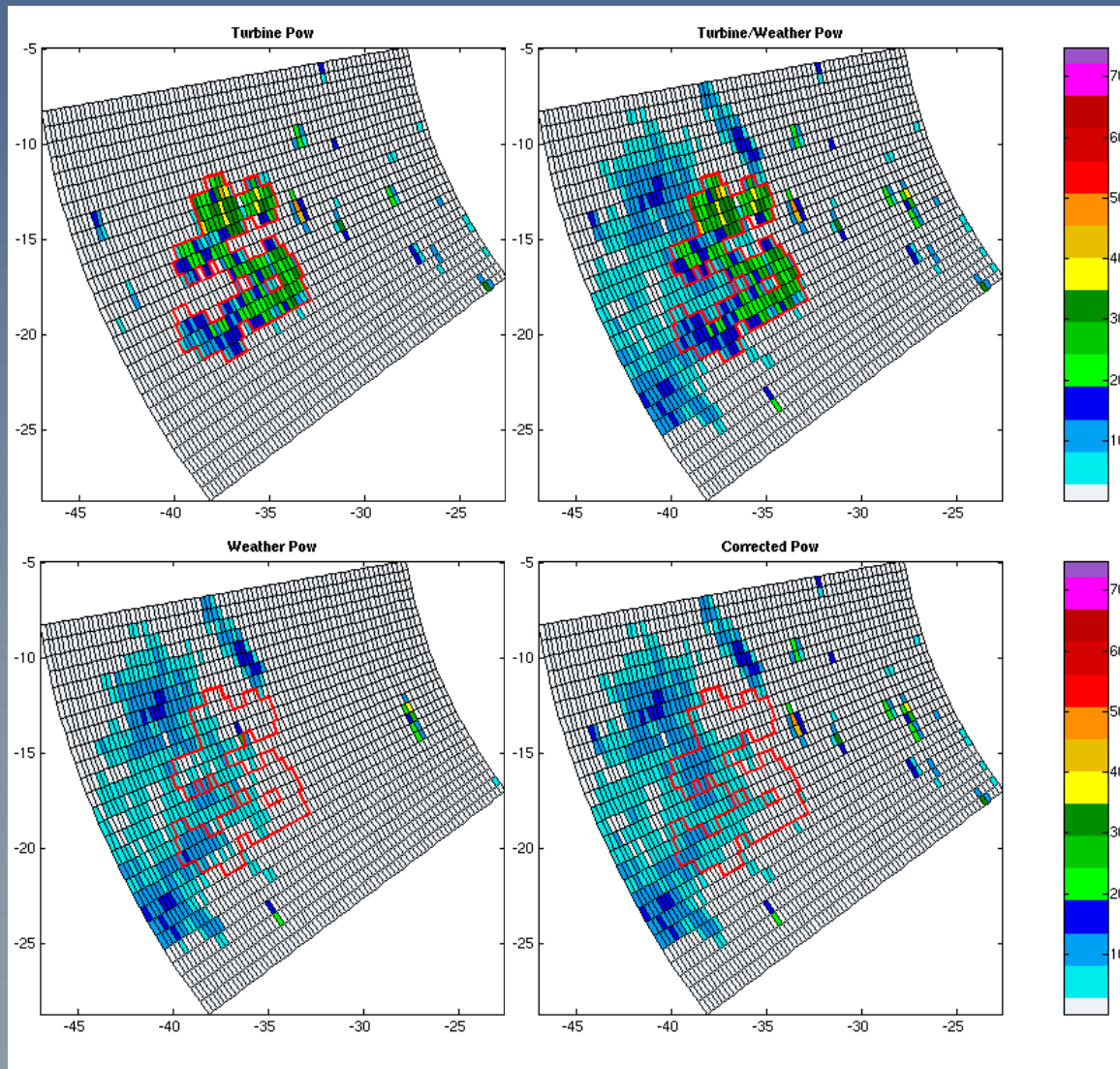# Level-II Interpolation Results
KDDC, 3D Interpolation Reflectivity

Level-II Interpolation Results
KDDC, 3D Interpolation Reflectivity

Level-II Interpolation Results
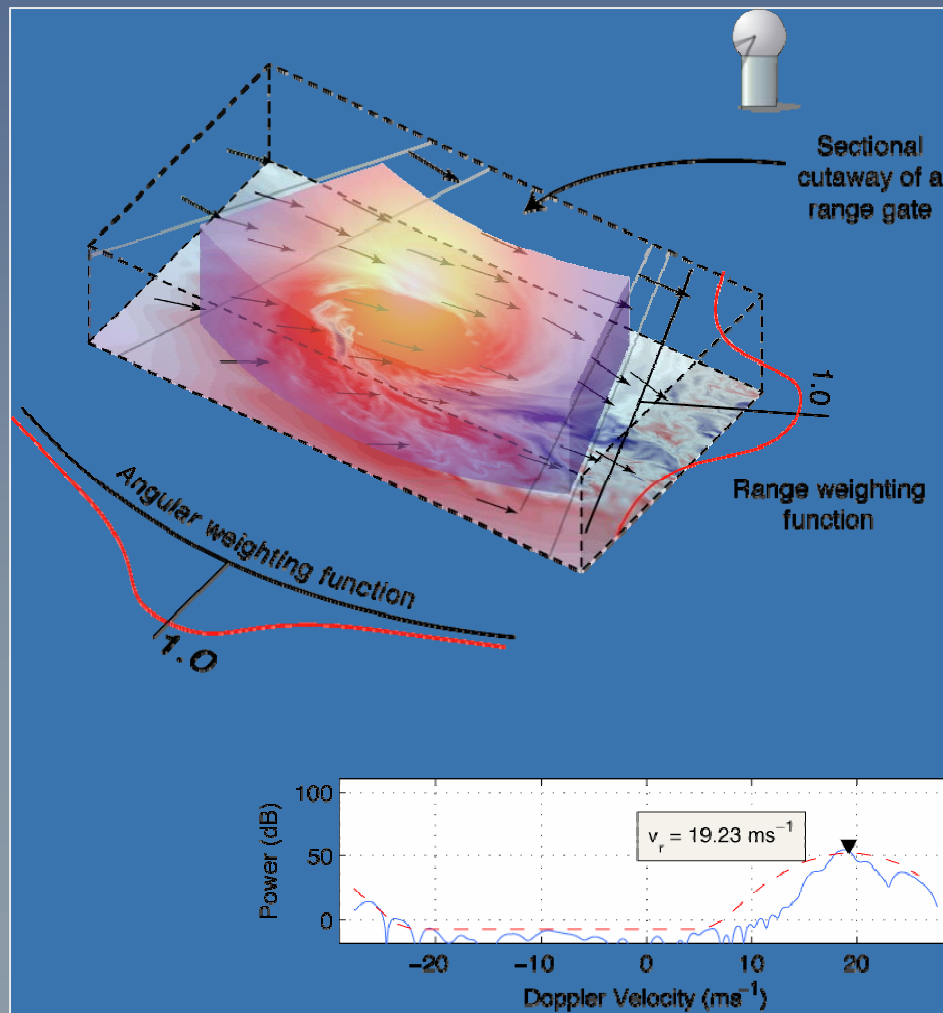## *KDDC, 3D Interpolation Reflectivity*

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The Doppler Spectrum
Unraveling radial velocities

The Doppler spectrum is a power-weighted distribution of radial velocities within the resolution volume
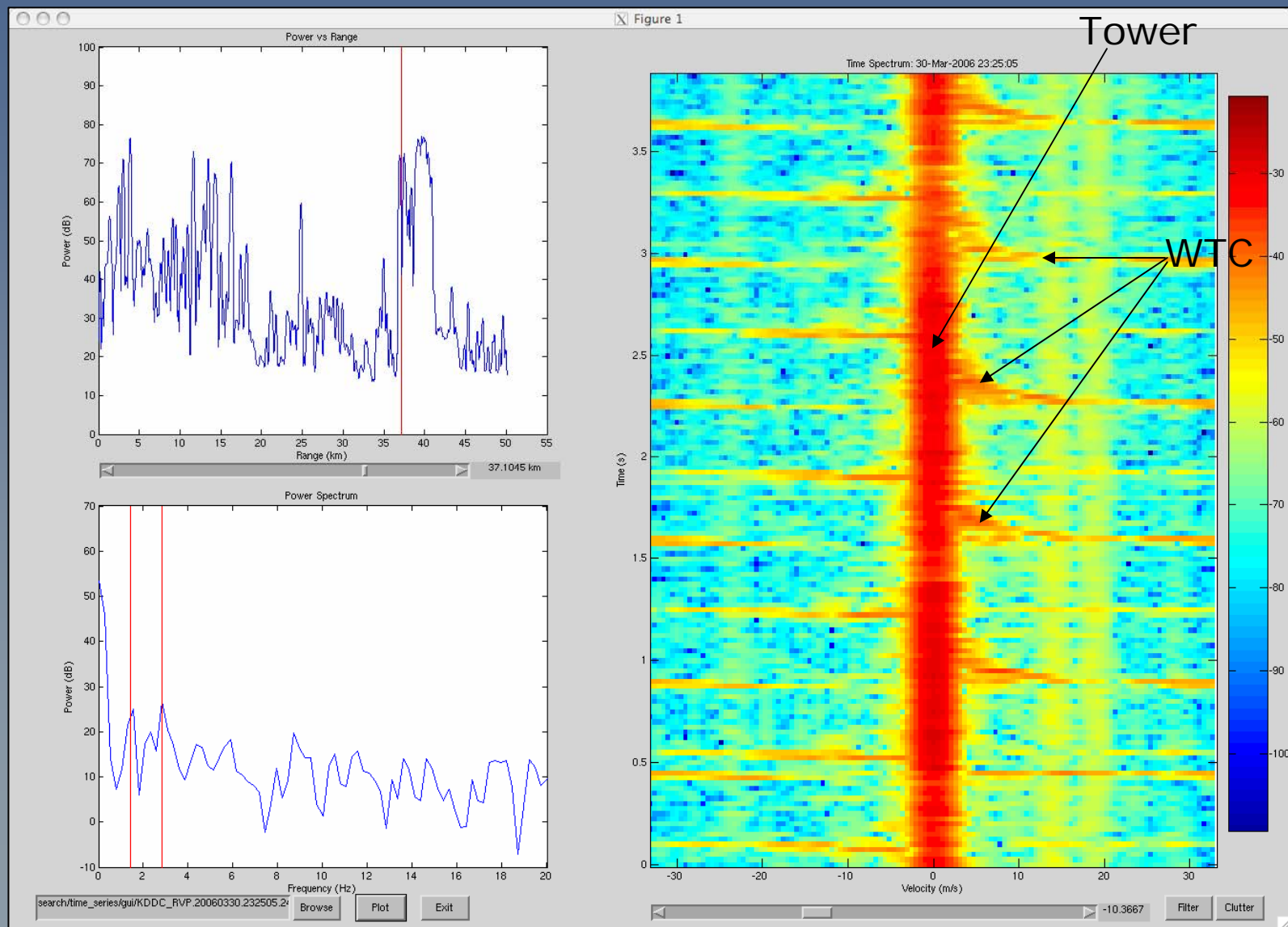
Examples of unique velocity distributions:
- *Tornados*
- *Ground Clutter*
- *Sea Clutter*
- *Birds*
- *Wind Turbine Clutter (WTC)*
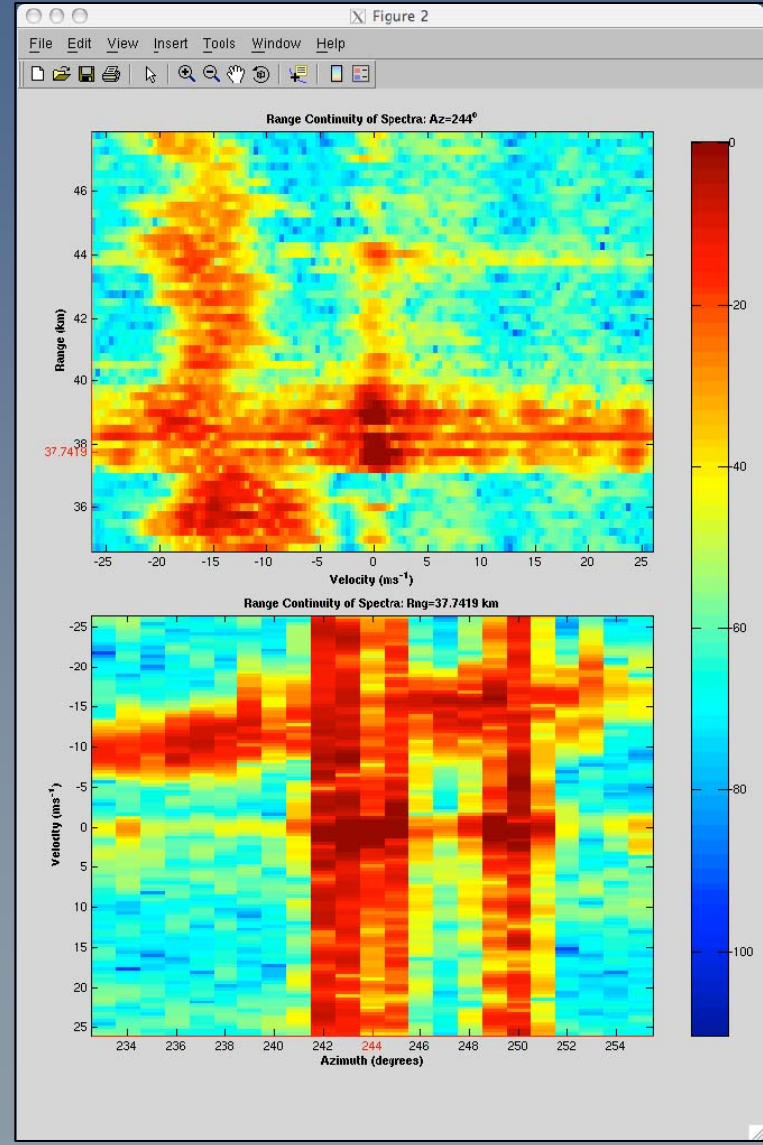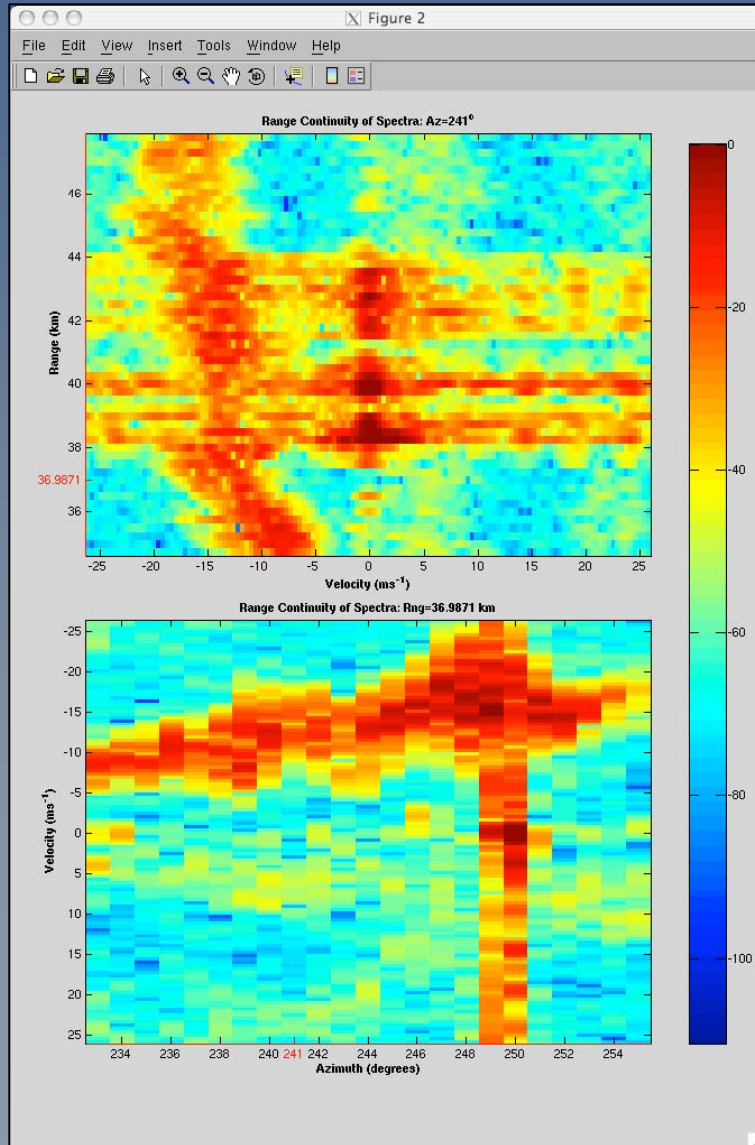
Spectral Processing Possible With ORDA

KDDC Spotlight
Single Isolated Turbine

KDDC VCP 21 Scanning Data
WTC & Wx: Range/Azimuth Continuity in Doppler Spectra

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47.5039 –111.4387   47.5061 –111.4392

47.5012 –111.4380

47.4992 –111.4376

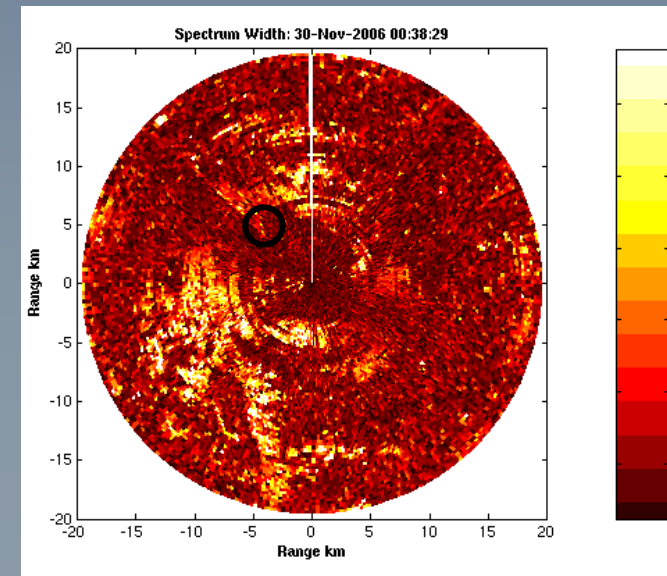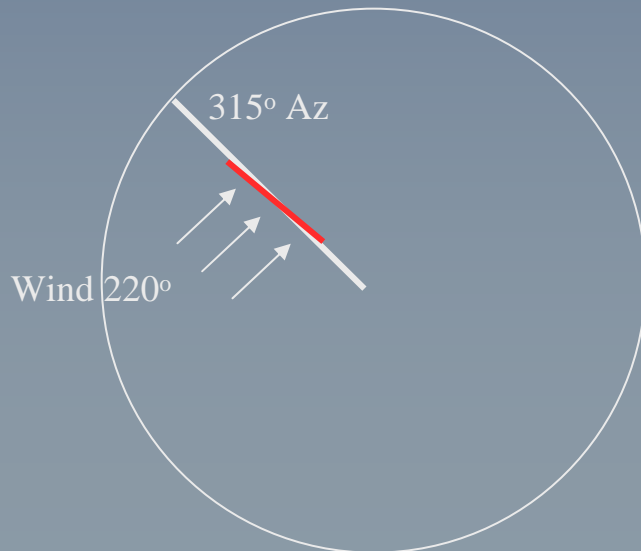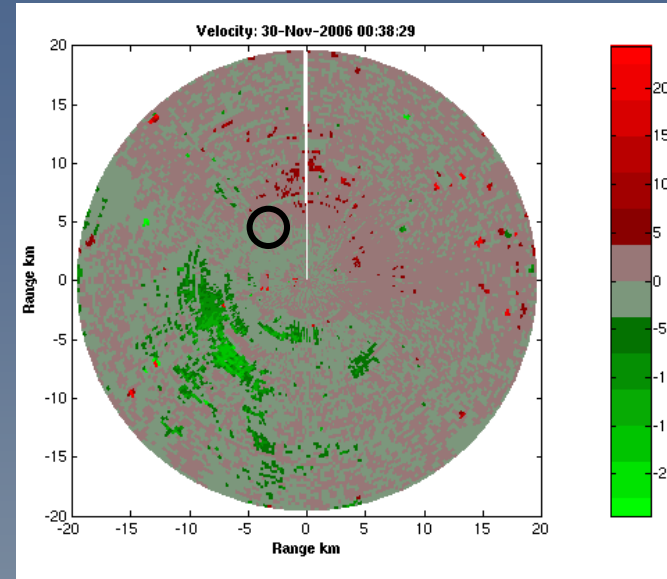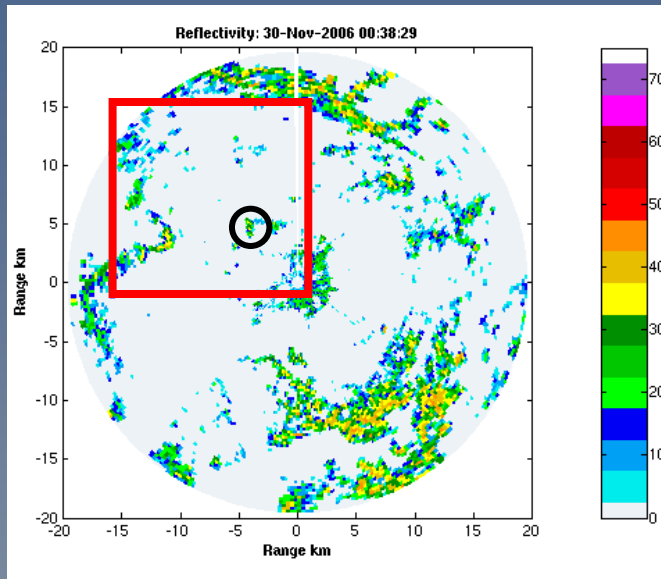47.4953 –111.4367   47.4973 –111.4371
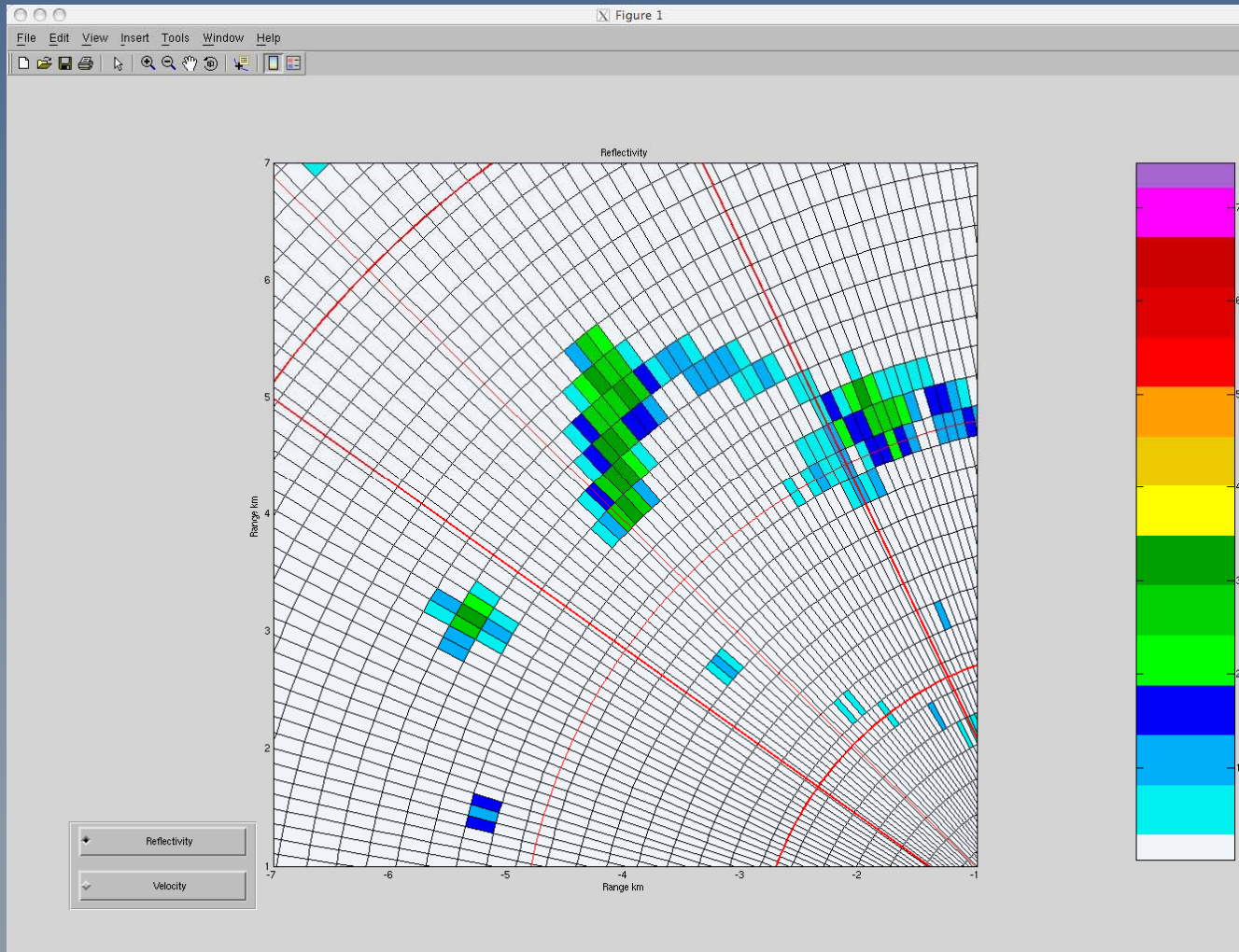
47.4597 –111.3853

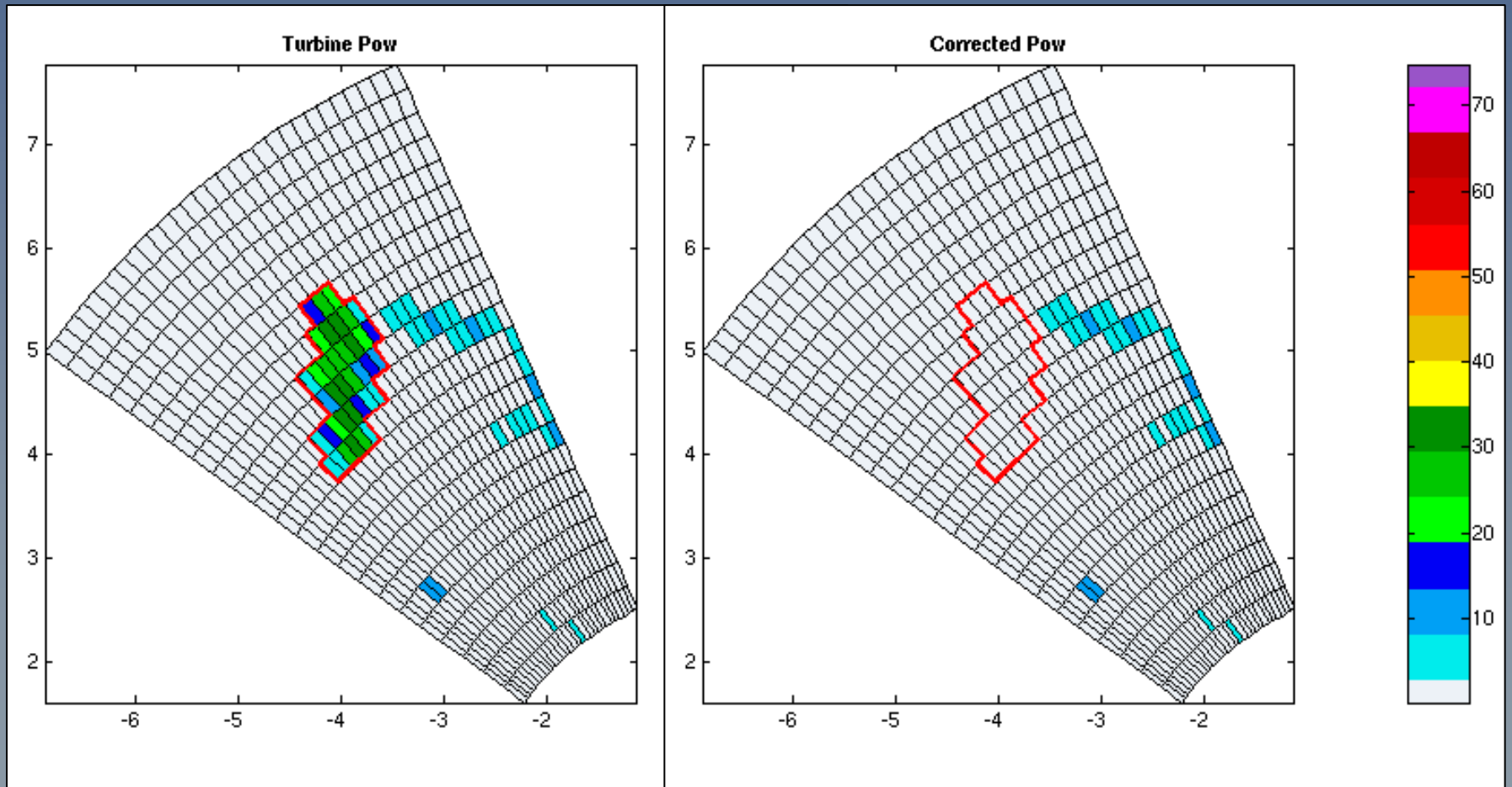# KTFX Level-II Example
November 30, 2006

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 Spectral Effects
KTFX, Multi-Trip and Wind Turbine Echoes

4-Way Trip

Primary
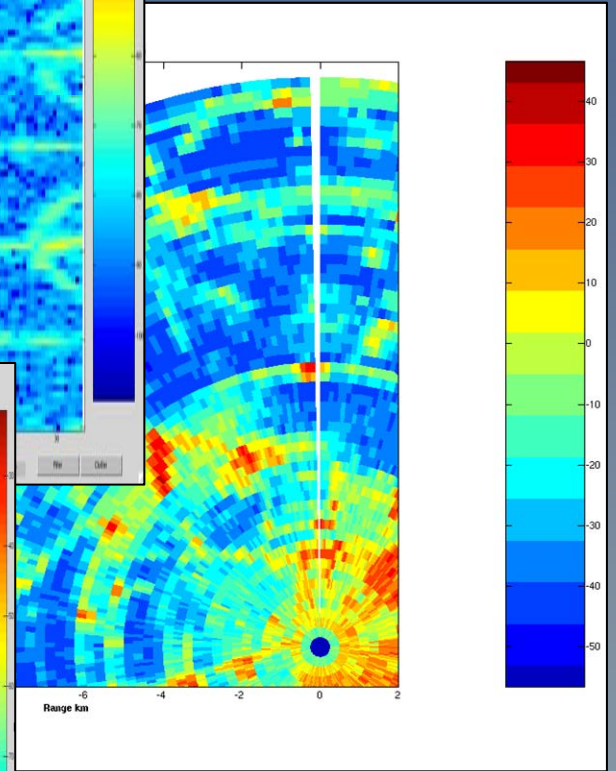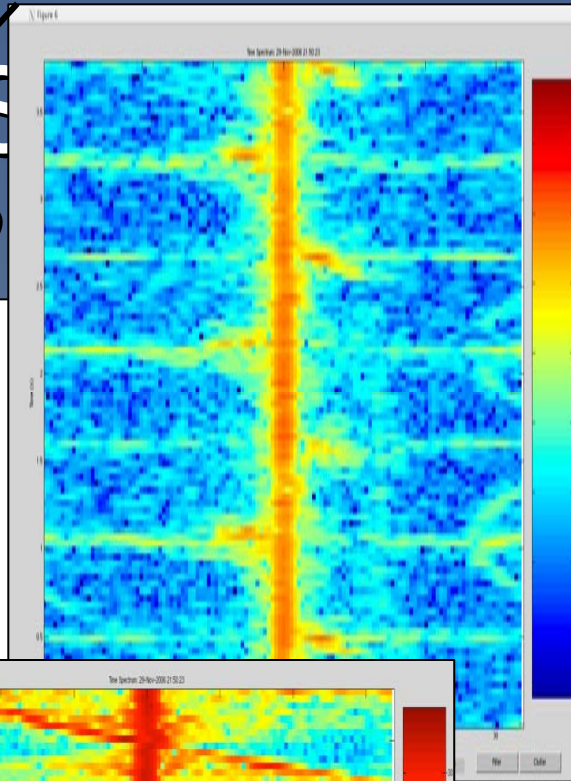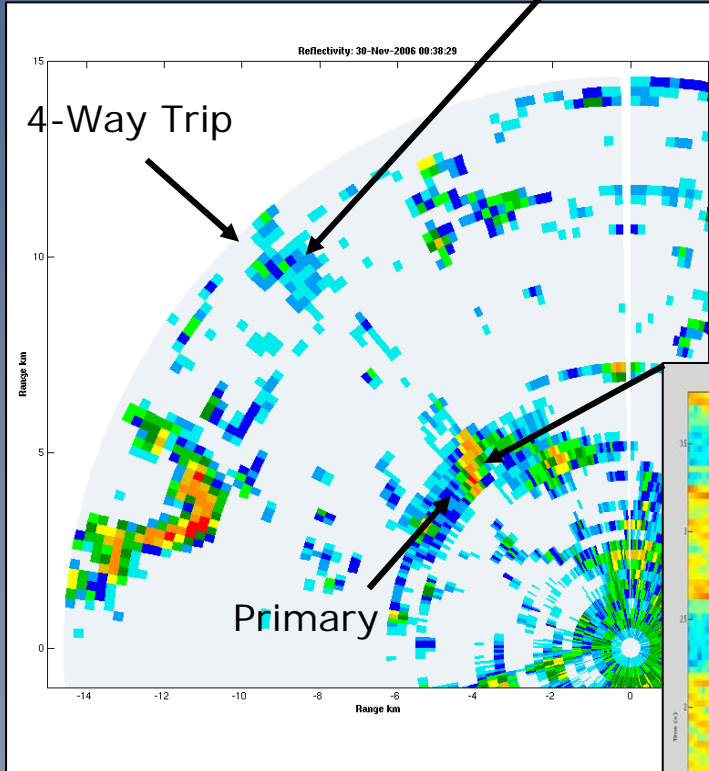
Multi-Trip Echoes

Turbine Interaction

"Body Scatter Spike"

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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