NEXRAD: LIVING WITH WIND TURBINE CLUTTER

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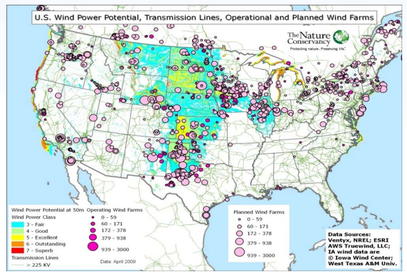
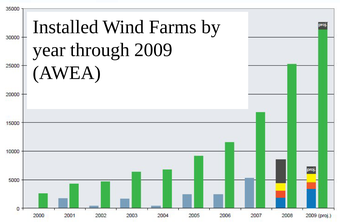
Growth of Wind Industry

Wind Resource and Wind Farm Distribution Map (Nature Conservancy)



Installed Wind Farms by year through 2009 (AWEA)



How We Learn About Wind Farm Developments

- National Telecommunications and Information Administration (NTIA)
- Weather Forecast Offices (WFO)
- Direct from developers or consultants
- FAA / Obstruction Evaluation /Airport Airspace Analysis (OE/AAA)

How We Analyze Impacts

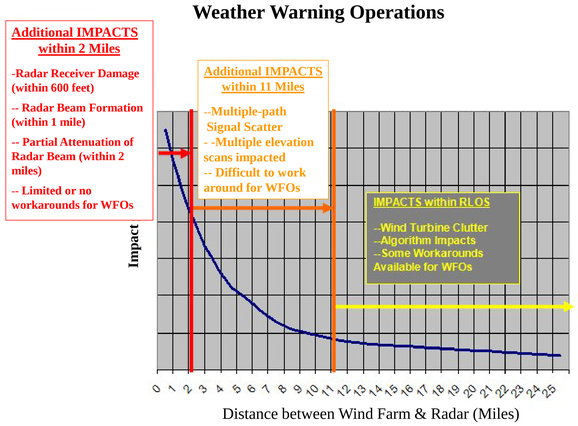
- Objective scoring based on both data and operational impact
  - Operational impact score based on severe weather climatology
  - Data impact score based on distance from radar, size of wind farm, number of turbines, and number of elevation angles impacted
- Both scores are put into a risk matrix to determine overall impact and follow-up strategy with developers

Impact Risk Matrix

Legend	
Red	**High impact risk** - ROC will follow-up with developer to discuss impacts and mitigation options. We will work closely with the developer to find an acceptable solution.
Orange	**Moderate impact risk** - Follow-up requested to discuss impacts and mitigations for developer's consideration.
Yellow	**Low impact risk** - No further analysis or follow-up requested. For this and future projects developers should consider mitigation options listed in this report.

How Wind Turbines Impact WSR-88D

Estimated Potential Wind Turbine Impacts on Weather Warning Operations



- Beyond ~11 miles (18 km) impacts are usually minimal and confined to first elevation angle (assuming level terrain) and wind farm area
- Within 11 miles impacts are cumulative with decreasing distance, rise dramatically, and extend beyond the wind farm area
- Within 2 miles (3 km) several elevation angles can be impacted, radar beam attenuation becomes significant, and forecasters have few workarounds

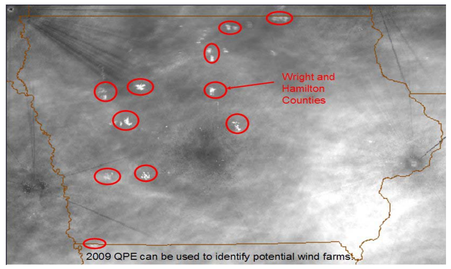
Why We Have to Live with Wind Turbine Clutter (WTC)

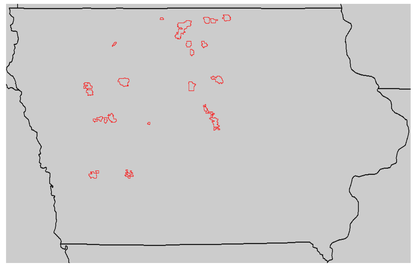
- WTC can be a nuisance….. real issue is potential impact to warnings/operations
- Competing national priorities: renewable energy and public safety
- No federal land-use decision authority on private property
- Anti-lobbying Act prevents use of appropriated funds for activities intended or designed to influence an official regarding and legislation , law, ratification, policy, or appropriation
  - Can answer questions on wind turbine impacts with facts
  - Can provide formal agency views through official channels

How to Live with WTC

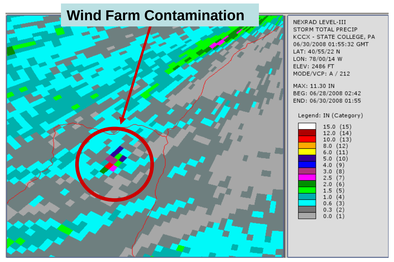
Workarounds Available to Forecasters

- Situational awareness… know where turbines are located
  - ROC collaborating with NSSL to generate AWIPS GIS overlays based on long-term QPE data

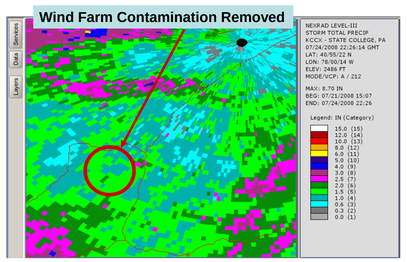




- Set-up exclusion zones over wind farms
  - Reduces QPE error without affecting base data
  - Exclusion zones only affect VCP angles below operator-selected elevation angle (e.g. entering 0.7° for an exclusion zone would only impact 0.5° elevation scan)

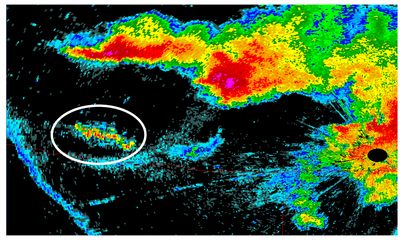


Storm Total Precip 28 – 30 Jun 08 without an Exclusion Zone

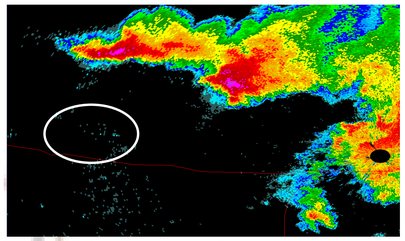


Storm Total Precip Product on 21 - 24 Jul 08 with Exclusion Zone over Wind Farm (Zone implemented on 07/10/08)

- Interrogate higher elevations angles



0.5° Base Reflectivity

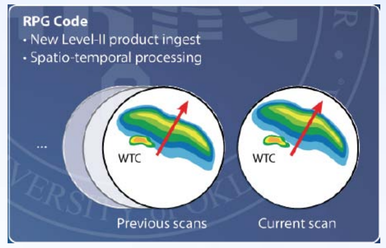


1.4° Base Reflectivity

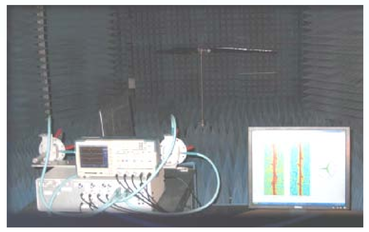
- Train staff / users / agencies / public
  - WDTB course "Wind Farms the WSR-88D and Co-existence" expected late 2010
  - Utilize ROC-developed wind farm/radar "fact sheets" and talking points
  - Discuss interference issues on WFO web pages and involve WCM on outreach/education
  - Visit ROC web site… includes section dedicated to wind farm-radar interaction

Potential Radar-Based Solutions for WTC

- ROC funding University of Oklahoma; studying two strategies
  - Automatically identify WTC using level II data and provide users with a confidence level of identification
    - Next Steps
      - ✓ Additional algorithm testing
      - ✓ Potentially migrate algorithm to RPG



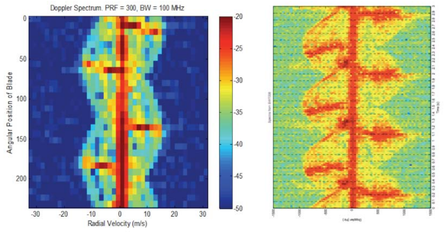
  - Characterize WTC using small-scale laboratory wind turbine model and miniature radar



Left image: Miniature radar in OU anechoic chamber; Center image: Scale model of wind turbine; Right image: computer-generated wind turbine for electromagnetic modeling studies

    - Next step: develop real-time mitigation algorithm in controlled laboratory environment
- Ultimate goal is operational signal processing solution… tough technical challenge

Comparison of key spectrum features between laboratory and field-measured data



Laboratory measured Field measured

Wind Industry Mitigation Options

- Keep wind turbines out of Radar Line Of Site (RLOS)
  - Siting farther from radar
  - Install shorter turbines
- Configure wind farm layout to reduce azimuthal impact
- Operational curtailment – Stopping turbines during pre-defined severe weather scenarios
- Sharing wind farm meteorological tower data

Future Strategy

- Continue outreach/education
- Work with American Wind Energy Association
- Work on national policy opportunities
- Continue WSR-88D signal processing technical development
- Collaborate with other federal agencies
  - DOD/DHS/FAA
- Determine if Dual Polarization will help mitigate WTC

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