WEATHER RADARS AND WIND FARMS WORKING TOGETHER FOR MUTUAL BENEFIT

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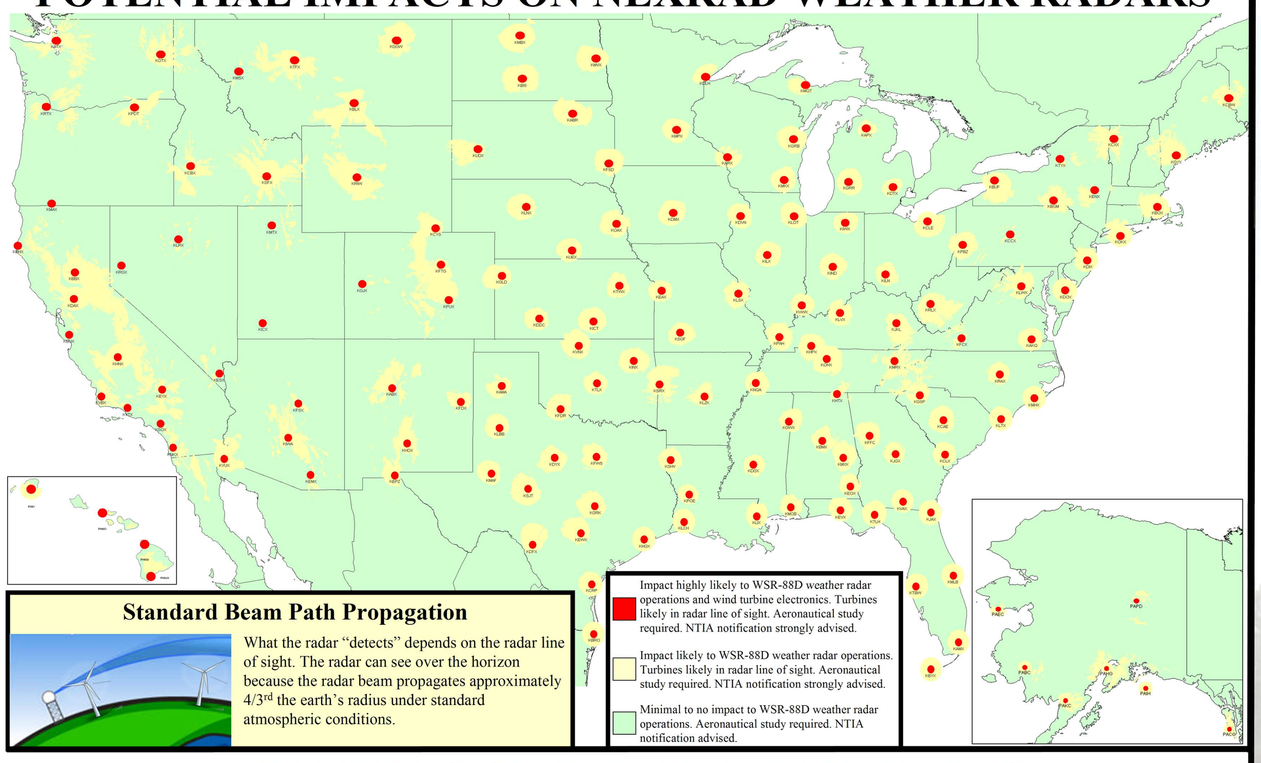
POTENTIAL IMPACTS ON NEXRAD WEATHER RADARS



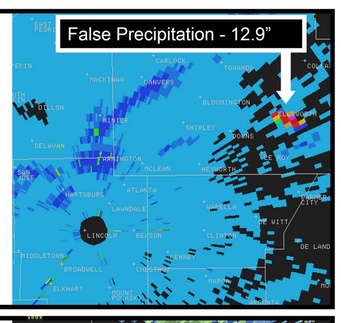
Standard Beam Path Propagation

What the radar "detects" depends on the radar line of sight. The radar can see over the horizon because the radar beam propagates approximately 4/3rd the earth's radius under standard atmospheric conditions.

EXAMPLES OF WIND FARM IMPACTS ON WEATHER RADARS AND USERS

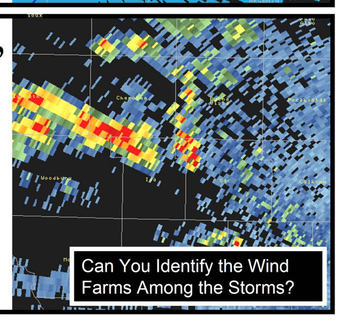
Lincoln, IL.

Excessive precipitation accumulation from this wind farm could result in a false flashflood warning.

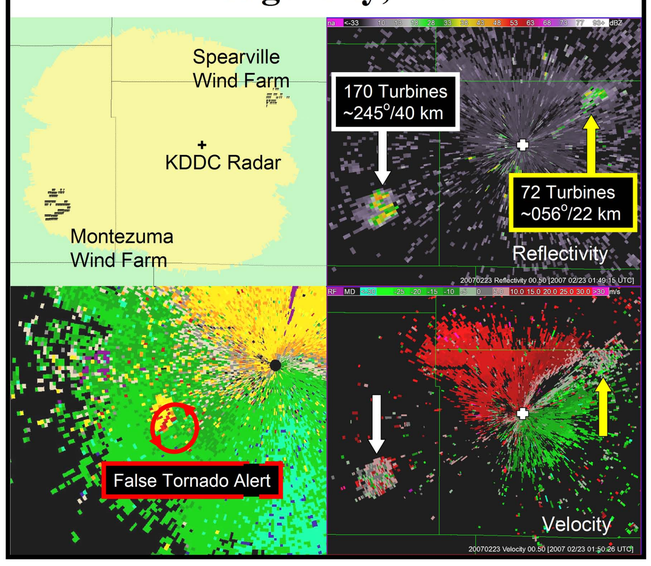


Des Moines, IA.

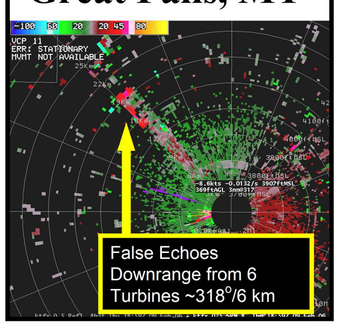
Emergency manager confusion on location of wind farms and developing storms.



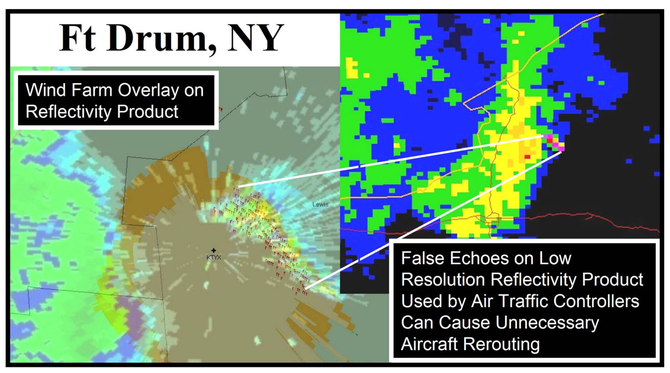
Dodge City, KS



Great Falls, MT



Ft Drum, NY



HOW WIND FARMS CAN IMPACT WEATHER RADARS

- **Potential Impacts on NEXRAD Data**
  - Spinning turbine blades inhibit radar's ability to filter turbine echoes and turbine clutter
  - Turbines can look like storms or severe weather on radar
  - Turbines can cause partial beam blockage, shadow effects, false echoes downrange
- **Effects on NEXRAD Products Near Wind Farms**
  - False and anomalously large precipitation estimates
  - Incorrect wind speed estimates
  - Missed/delayed tornado and thunderstorm detections or false alarms
  - False and anomalously large reflectivity estimates
  - False storm identification and incorrect storm track forecasts
- **Potential Impacts on Weather Forecasts and Warnings for**
  - Tornadoes
  - Flash Floods
  - Winter Storms
  - Air Traffic Control and Routing

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http://arrc.ou.edu/turbine

NEXRAD NETWORK

- Operated by Federal Departments of Commerce, Transportation, and Defense
- Data available worldwide and used by government meteorologists, emergency managers, television broadcasters, private industry, researchers, and the public
- Data from network utilized to issue tornado/severe weather/flashflood warnings, weather forecasts, and hydrological forecasts which protect citizens, reduce property damage, and improve air traffic efficiency and safety
- Independent scientific analysis verified the use of NEXRAD data has reduced expected tornado fatalities by 45% and expected injuries by 40%

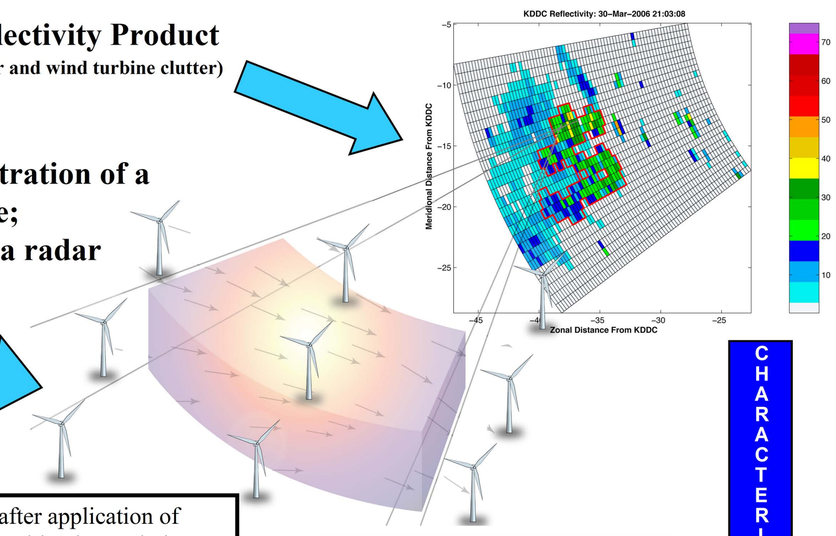
NEXRAD COMPARED TO AIR SURVEILLANCE RADAR (ASR)

- ***Many techniques used to mitigate effects of wind turbine clutter on the ASR are <u>not</u> applicable to the NEXRAD***
- Targets of interest are significantly different; Distributed vs. Point Targets
  - Weather (Distributed): rain, snow, hail, particulates (diffuse, weak); many different Doppler velocities (e.g., turbulence, wind shear)
  - Aircraft (Point): hard, very reflective; more distinct Doppler velocity
- NEXRAD designed with greater sensitivity (lower noise floor) than ASR systems; signals are processed differently resulting in different clutter solutions

CURRENT MITIGATION STUDIES

Radar Reflectivity Product
(Includes weather and wind turbine clutter)

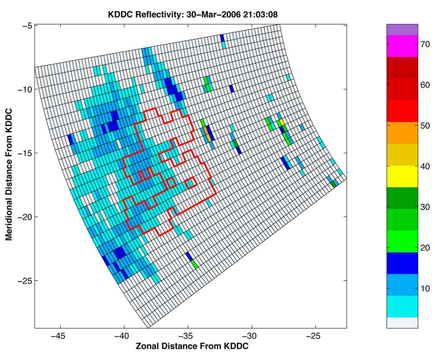
Three dimensional illustration of a radar resolution volume; represents one pixel on a radar product.



Depiction of reflectivity product after application of experimental wind turbine clutter mitigation technique

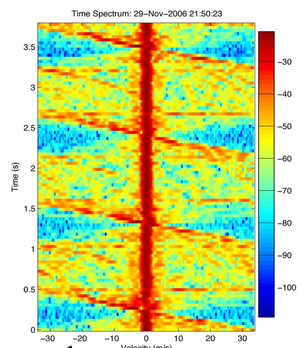
On-going signal processing study to develop techniques for mitigating wind turbine clutter

CHARACTERIZATION



GOAL

Reduce the appearance of wind turbine returns in radar data



- Research Opportunities Exist
  - Advanced signal processing methods using NEXRAD and phased array radars
  - Laboratory experiments hold promise for turbine-feedback based filtering
- Several effects of wind turbine clutter on NEXRAD will be difficult if not impossible to eliminate (e.g., shadowing, multipath scatter)
- See poster *Wind Turbine Clutter Characterization and Mitigation on Federal Weather Radars (NEXRAD)* for additional details

SUMMARY

- **NEXRAD enables timely, accurate life-saving forecasts and warnings, as well as safe and efficient air transportation**
- **Wind farm interference can result in spurious echoes which are difficult to mitigate, reduce radar algorithm performance, and confuse radar users**
- **Our studies are revealing more about wind farm impacts on weather radars and possible mitigation techniques**
- **We want to work with the wind energy industry on siting decisions to ensure mutual success of our National roles**
  - **Best mitigation is to keep wind turbines *outside the radar line of sight***
  - **Recommend developers coordinate with the National Telecommunications Information Administration (NTIA) early in the siting process**
- **We have successfully worked with some developers to mitigate impacts to both turbines and radars**