Recent Changes to NOAA's Wind Turbine Impact Evaluation Process and Mitigation Efforts

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NEXRAD Weather Radar Overview

- **NEXRAD (Next Generation Weather Radar)**
  - Also known as the “WSR-88D”
  - Network of 159 radars operated by NWS, USAF, FAA
  - Doppler radar designed to detect weather targets and storm-scale winds
  - 750 KW, S-band, ~1° “pencil” beam
  - Source of many radar images on TV; all **weather.gov**
- **Cornerstone of:**
  - Weather forecasts and severe weather warnings – protects life and property
  - Safe and efficient aircraft operations – supports the National Airspace System
  - Enhancement of national economy – data used by public and private sector

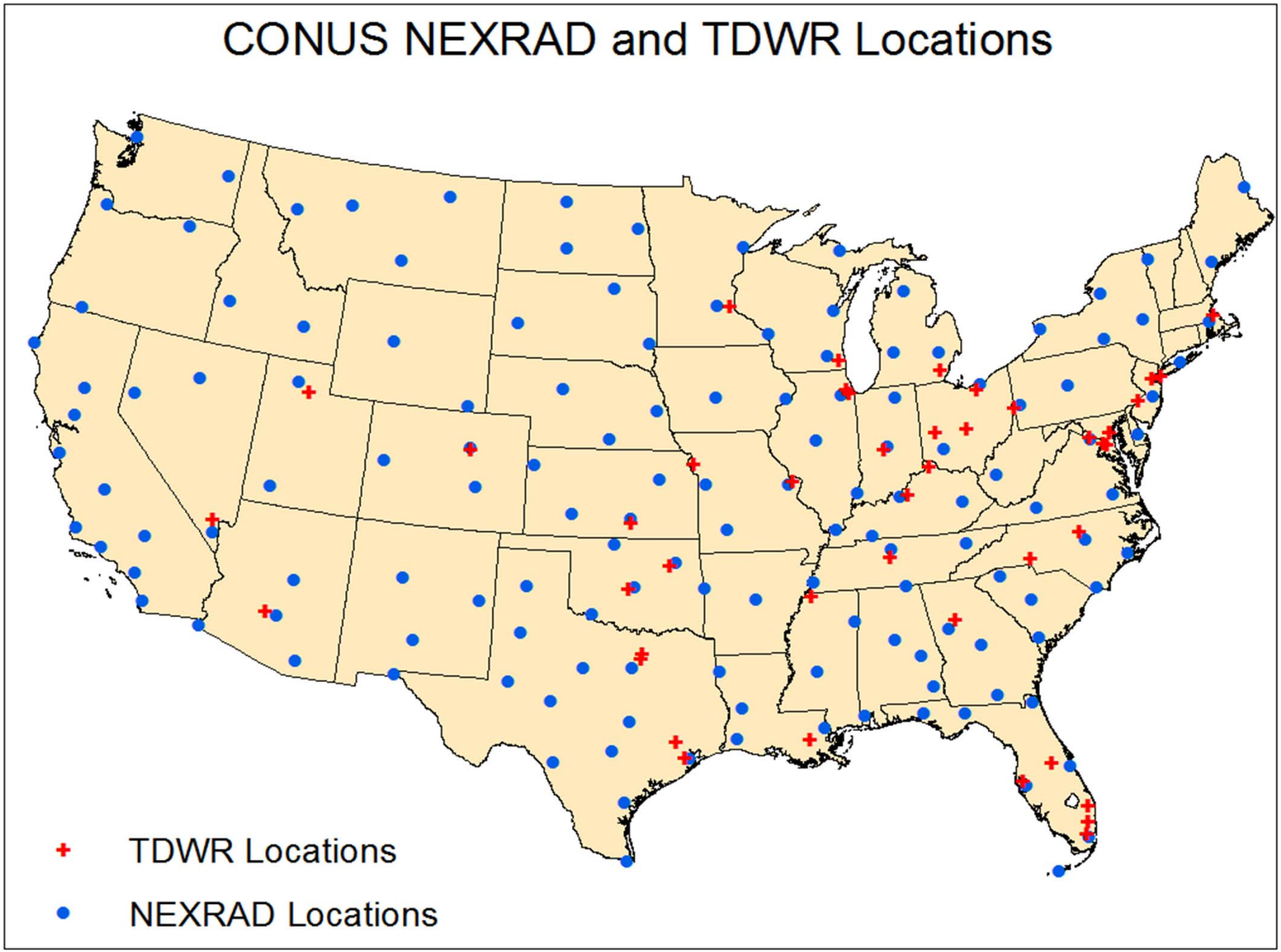
“The development of the NEXRAD ... led to major improvements in capabilities of measuring winds, detecting tornadoes, tracking hurricanes, and estimating rainfall.” (National Academy of Sciences, 2002)

TDWR Weather Radar Overview

- **TDWR (Terminal Doppler Weather Radar)**
  - 45 radars operated by FAA
  - Located near large airports with a significant exposure of low-altitude wind shear
  - Doppler radar designed to detect microbursts and weather targets
  - 250 KW, C-band, ~0.55° “pencil” beam

- **Cornerstone of:**
  - Safe and efficient aircraft operations – supports the airport terminal operations / National Airspace System (e.g., your flight home)
  - Data products supplement NEXRAD in severe weather warning operations – used by public and private sector

“NWS weather forecast offices have documented cases where TDWR data enabled life-saving severe weather warnings that would otherwise been missed.”


CONUS NEXRAD and TDWR Locations
TDWR Locations
NEXRAD Locations

How Can "Wind Turbine Clutter" (WTC) Impact Weather Radar Data

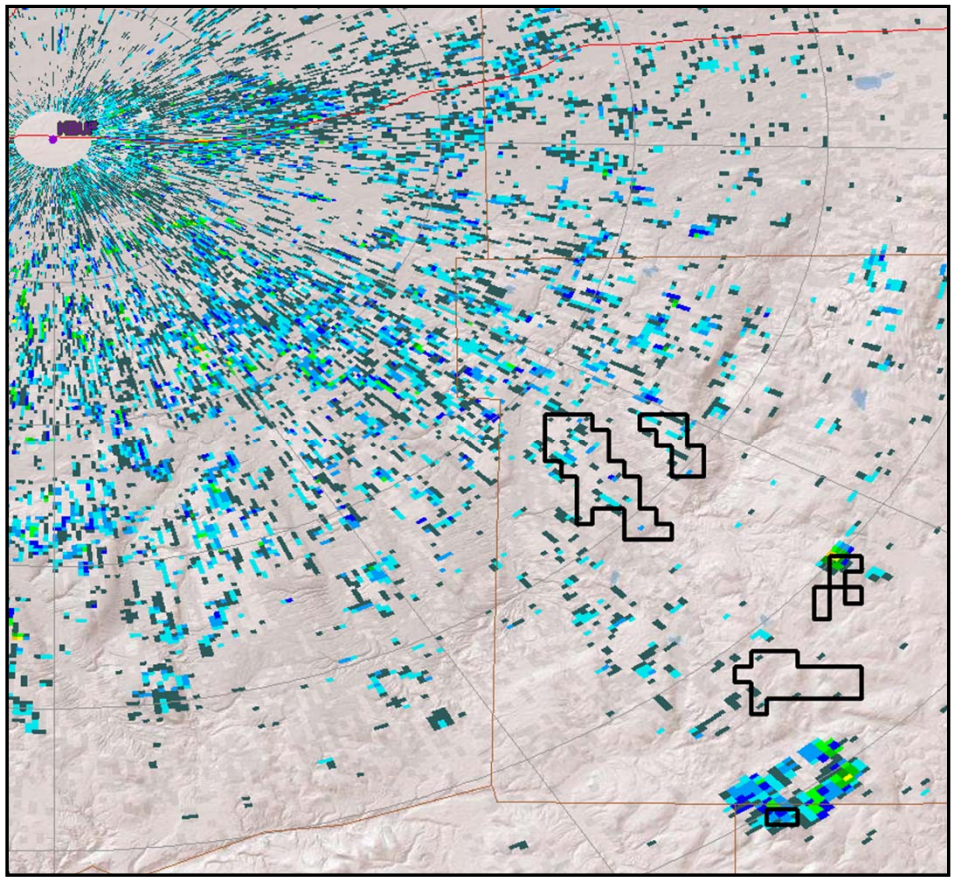
- Rotating turbine blades in radar line of sight (RLOS) return signals; appear very similar to weather returns/echoes
  - Impact data quality and performance of numerous radar algorithms
  - In "heat of battle" of issuing weather warnings, seconds count toward warning lead time
- Not all WTC is equally important to weather radar users
  - We focus on impacts to federal forecasters/users that degrade their capability to issue timely and accurate severe weather warnings
  - However, the publically-available imagery can confuse "casual" users

WTC Issues/Challenges

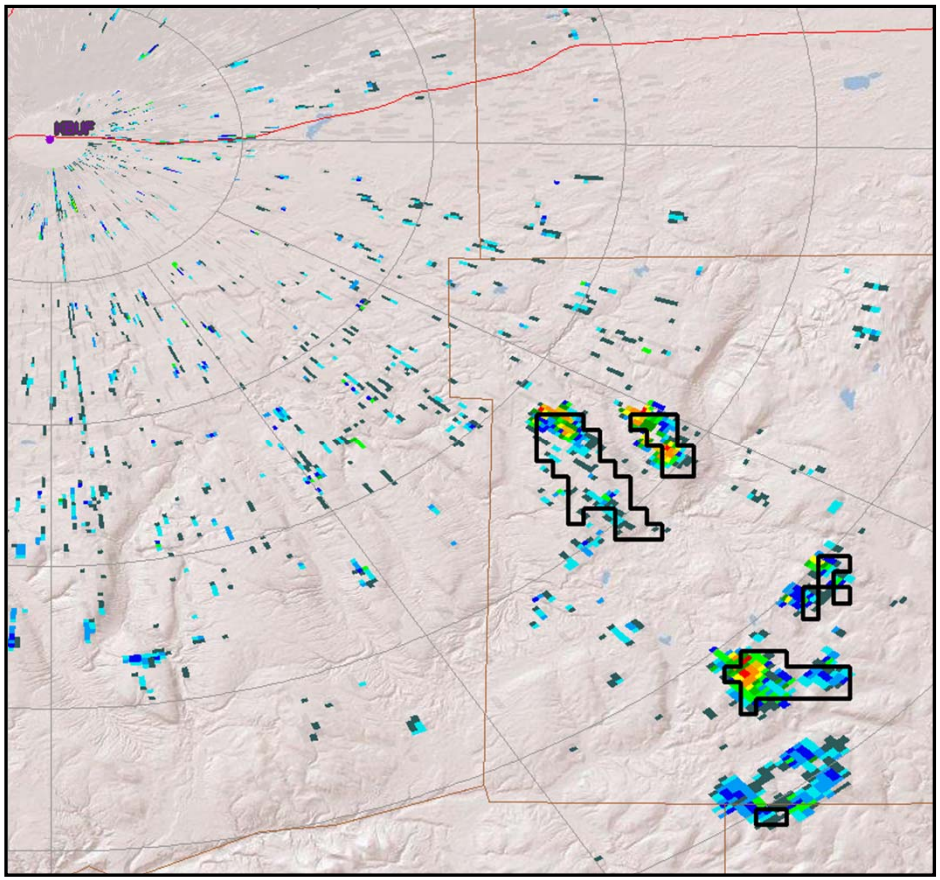
- Rapid growth in number and size of wind turbines
- Competing National priorities….but no legal framework to protect the nation's weather radar networks from encroachment
- Filtering WTC while preserving critical weather radar data -- a big technical challenge
- Very limited NOAA/NWS funding for weather radar mitigation studies, in-fil radars, other mitigation strategies/solutions

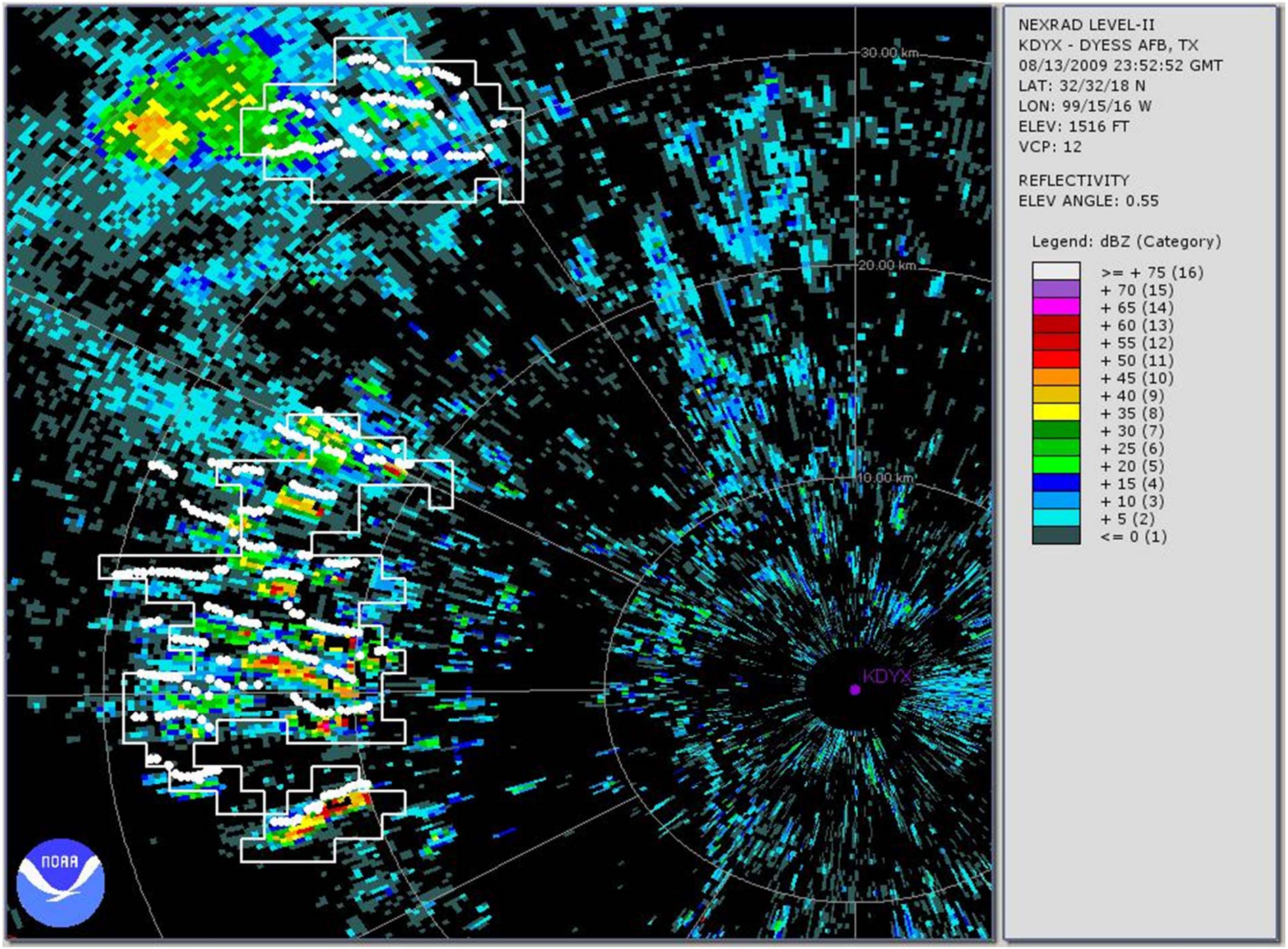
What Does WTC Look Like on Weather Radars?

Buffalo NEXRAD Before Wind Farms



Buffalo NEXRAD After Wind Farms




30.00 km
20.00 km
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KDYX
NEXRAD LEVEL-II
KDYX - DYESS AFB, TX
08/13/2009 23:52:52 GMT
LAT: 32/32/18 N
LON: 99/15/16 W
ELEV: 1516 FT
VCP: 12
REFLECTIVITY
ELEV ANGLE: 0.55
Legend: dBZ (Category)
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+ 60 (13)
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+ 50 (11)
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+ 40 (9)
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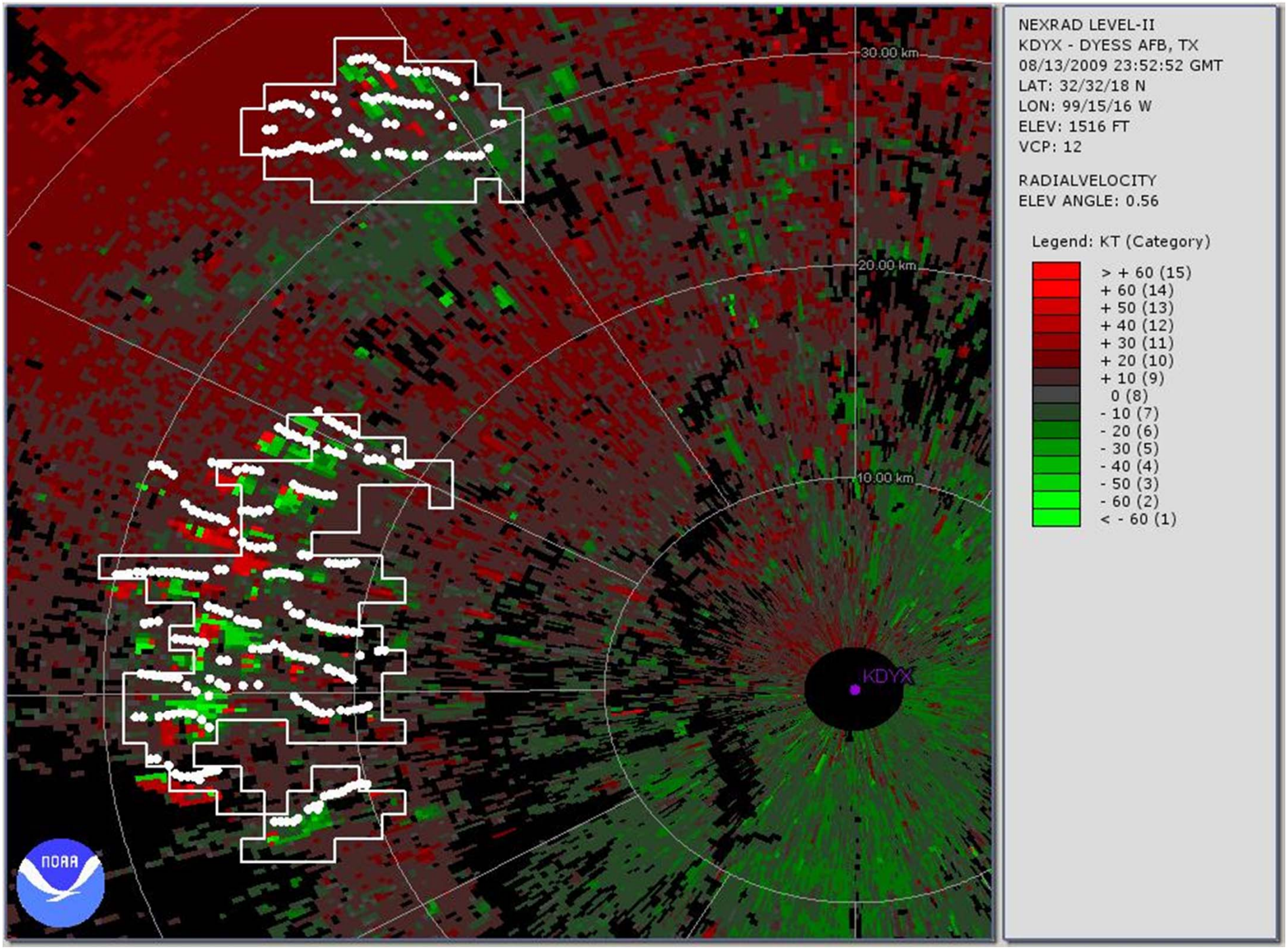
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RADIALVELOCITY
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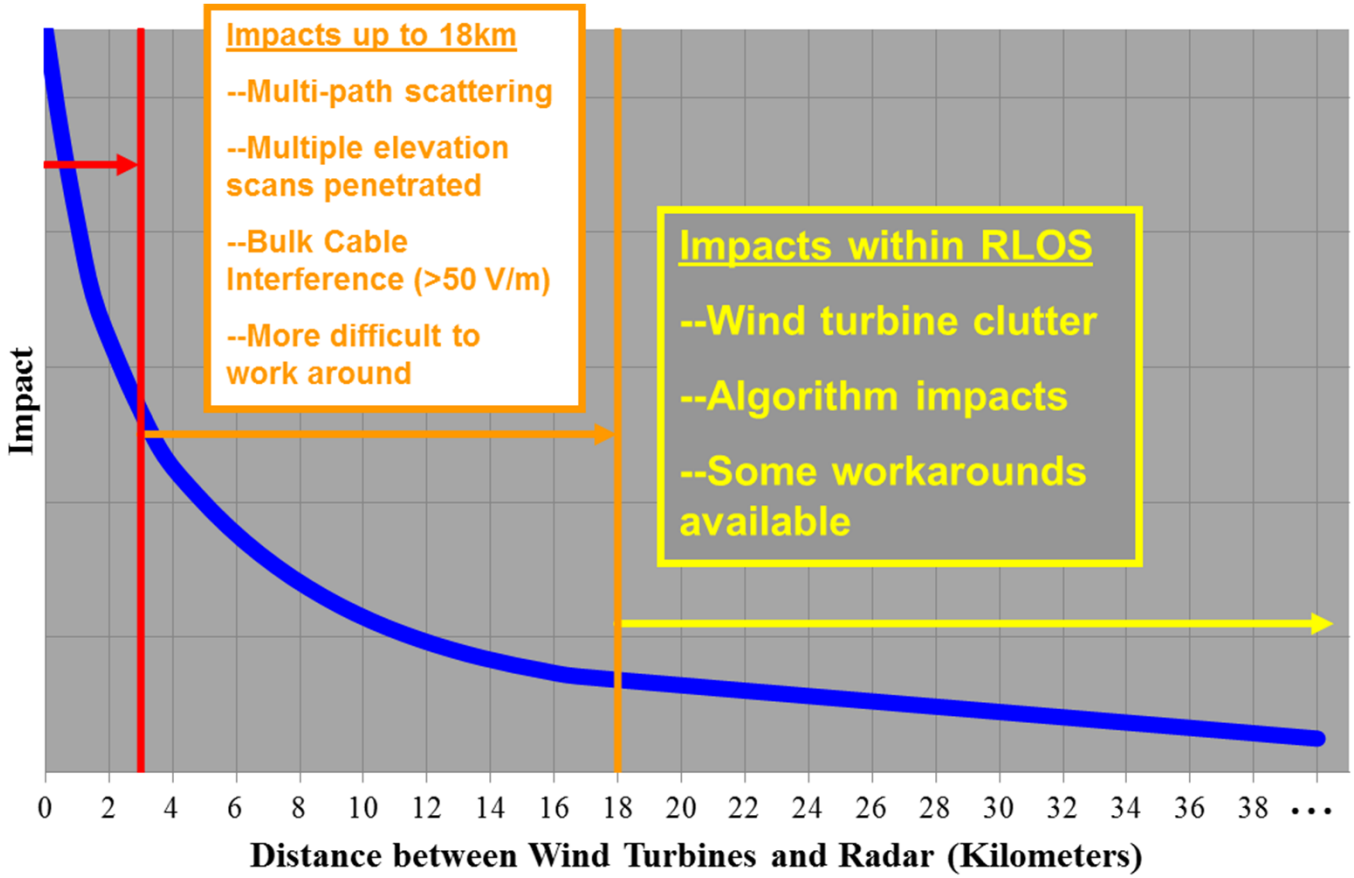
Nearby Wind Turbines Can Impact Radar and Severe Weather Operations

Impacts up to 3km

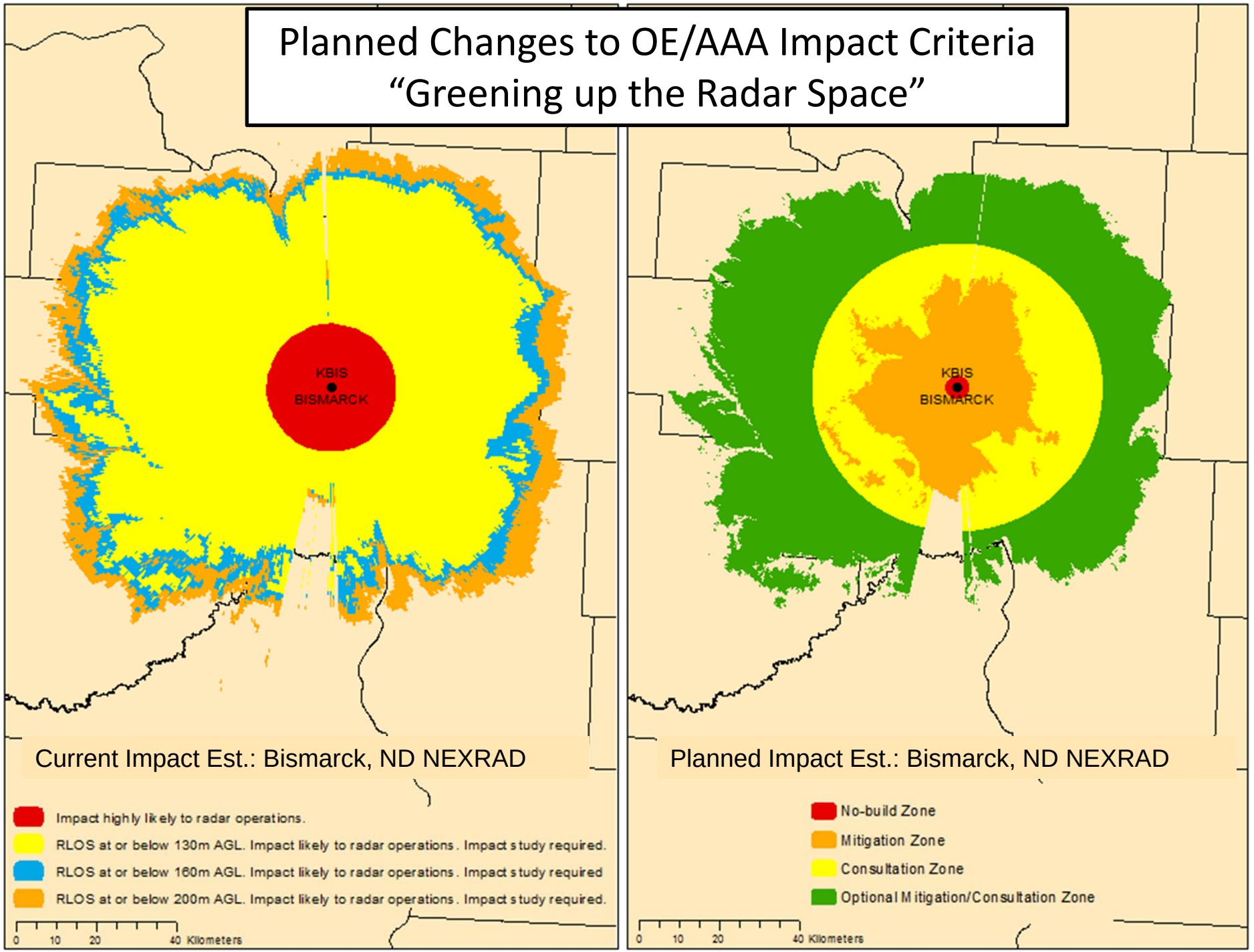
- --Receiver Damage (if >53 dBm returned)
- --Nacelles can block beam (within 3km)
- --Blades can block beam (within 1km)
- --Personnel Safety (within 200 meters)
- --Limited or no forecaster workarounds



Recent NWS Initiatives on WTC Mitigation

- Developing new OE/AAA NEXRAD Preliminary Screening Tool maps: more closely match recently-refined impact criteria; more wind-energy friendly
  - Based on 4+ years experience, 800+ evaluations
- Developed on-line course “Wind Farms, the WSR-88D and Co-existence” for weather forecasters: http://www.wdtb.noaa.gov
- Developed GIS overlays that outline wind farms, show turbine locations

Planned Changes to OE/AAA Impact Criteria
"Greening up the Radar Space"



Recent NWS Initiatives on WTC Mitigation

(Continued)

- Funded (limited) studies of potential signal processing solutions at Univ. of Oklahoma's Atmospheric Radar Research Center (ARRC)
- Working with three wind energy companies to develop "Operational Curtailment of Wind Turbines During Severe Weather"— about 10 hrs/yr
- Participating in Interagency Task Force (DOE, DoD, DHS, FAA, others) to define short-, medium-, and long-term R & D strategies

Way Forward for Compatible Wind Energy Development

- Research Radar–based mitigations
- Research Wind Turbine–based mitigations
- Federal interagency collaboration: mutual interests, concerns, research, process improvement
- National “clearing house” for developers to submit project plans…..all federal agencies…..earlier impact assessment
- Add in-fill radars for coverage of blocked regions
- Federal statute providing radar protection…..No build zones, early consultation, mandatory consultation zones

Weather Radar Data Can Improve Wind Farm Efficiency

- Weather radar data can improve near-term numerical model forecasts if real-time radar data used as input
- Weather radar data/imagery can assist operators in “ramp” events; especially for decisions within ~2 hours, for example
  - Frontal boundary wind shift lines
  - Gust fronts from thunderstorms
  - Where/when severe weather may/may not impact a portion of a wind farm
- Dual Polarization modification; enhanced prediction/observation of:
  - Liquid/freezing/frozen precipitation
  - Rain rates
  - Identification of large bird movements

Useful Related URLs

- WSR-88D Radar Operations Center Wind Farm Interaction Page: http://www.roc.noaa.gov/windfarm/windfarm_index.asp
- Federal Aviation Administration Obstruction Evaluation / Airport Airspace Analysis (OE/AAA): https://www.oeaaa.faa.gov/oeaaa/external/portal.jsp
- National Telecommunications and Information Administration (NTIA) Interdepartmental Radio Advisory Committee (IRAC): http://www.ntia.doc.gov/osmhome/irac.html
- University of Oklahoma Atmospheric Radar Research Center: http://arrc.ou.edu/
- Contact us at: wind.energy.matters@noaa.gov