NEXRAD Weather Radars and Wind Turbines: What You Need to Know to Avoid Impacts and Successfully Develop your Project

AWEA AMERICAN WIND ENERGY ASSOCIATION

NEXRAD Weather Radars and Wind Turbines: What You Need to Know to Avoid Impacts and Successfully Develop your Project

Moderator:

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Speakers:

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WSR-88D and Wind Turbines

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NEXRAD Program

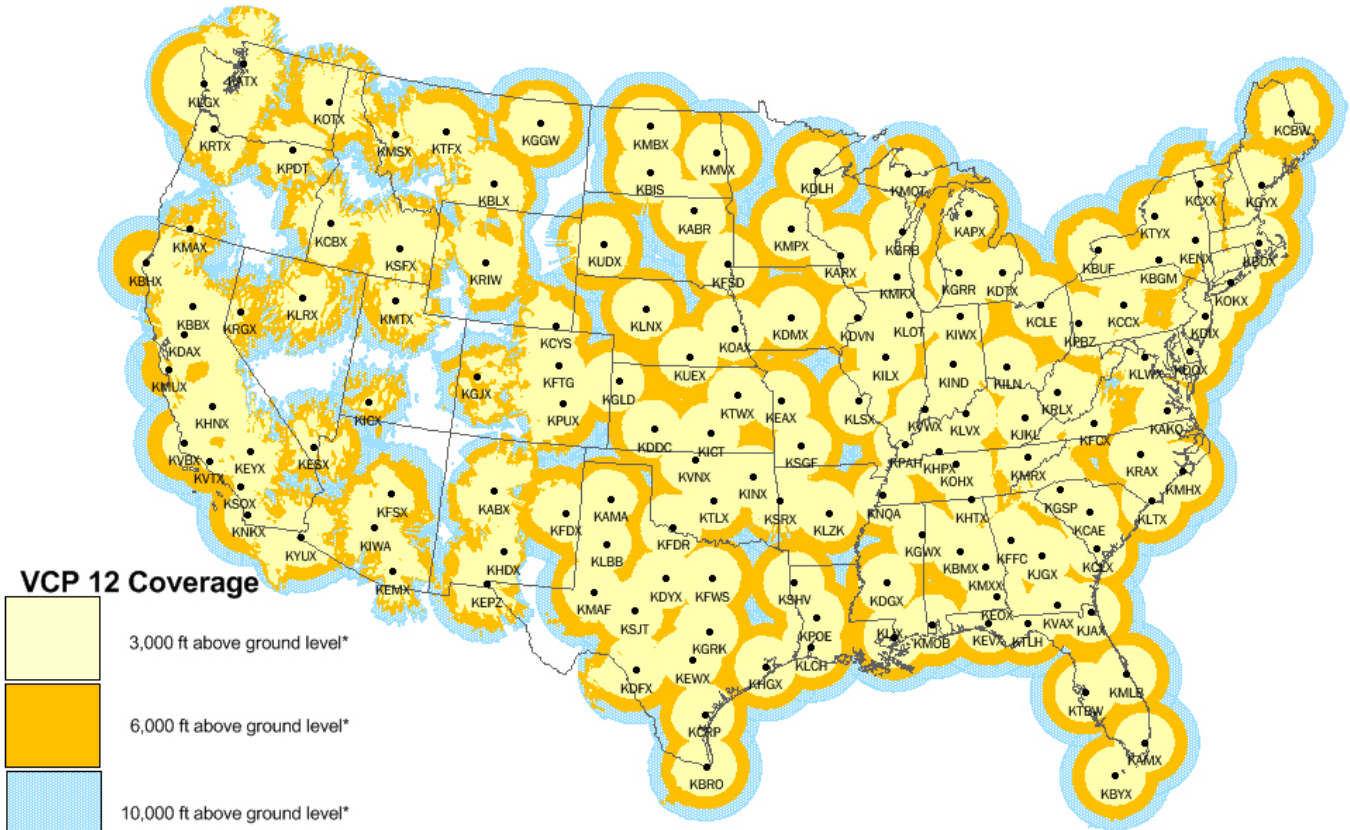
- NEXRAD:
  - **Nex**t Generation Weather **Rad**ar Program
- WSR-88D:
  - **W**eather **S**urveillance **R**adar – 19**88 D**oppler

The radar is referred to as the “WSR-88D” or the “NEXRAD”

NEXRAD Program

- Tri-Agency Funded:
  - Department of Commerce – National Weather Service
  - Department of Defense – Air Force Weather Agency
  - Department of Transportation – Federal Aviation Administration
- Purpose & Goals:
  - Establish a national network of weather radars
    - Forecasts, warnings
    - Safe, efficient aircraft operations
    - Enhancement of national economy
    - Resource protection of military assets and personnel
- Most WSR-88Ds deployed 1990-1996

NEXRAD Coverage Below 10,000 Feet AGL



VCP 12 Coverage

3,000 ft above ground level*

6,000 ft above ground level*

10,000 ft above ground level*

0 375 750

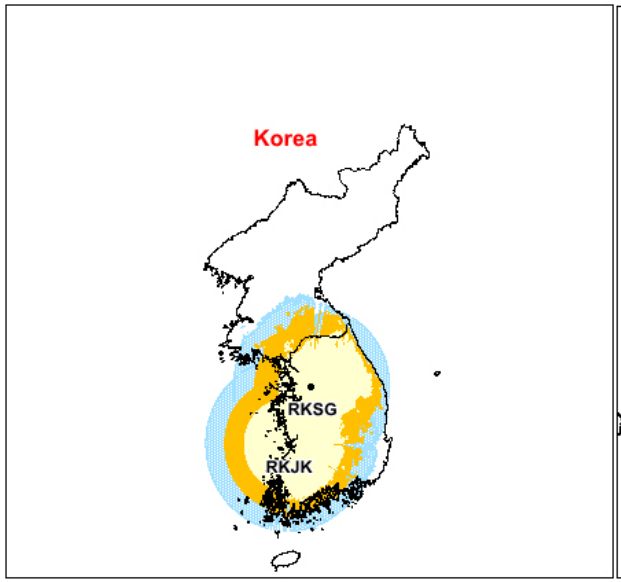
miles

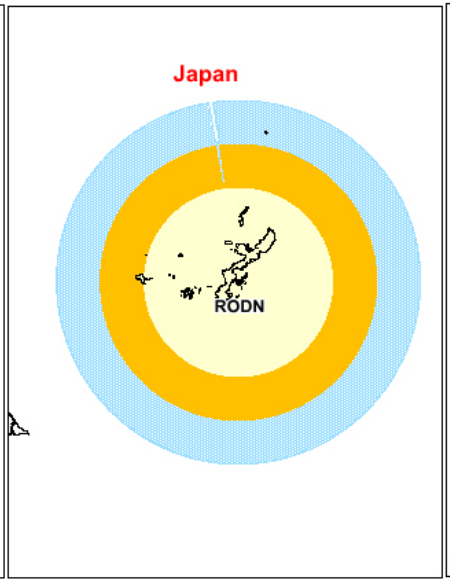
*Center of beam height (assuming Standard Atmospheric Refraction)
Terrain Blockage Indicated where 50% or more of beam blocked

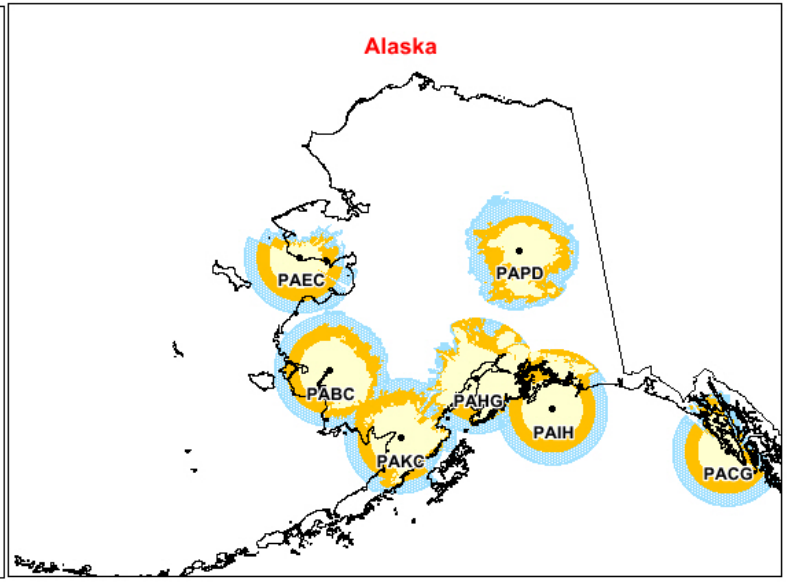
CONUS:
122 NWS Radars
21 DoD Radars

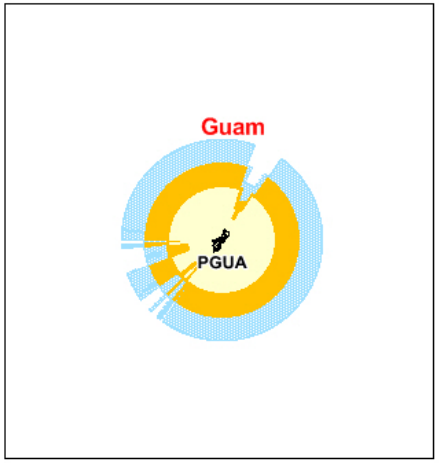
Puerto Rico: FAA

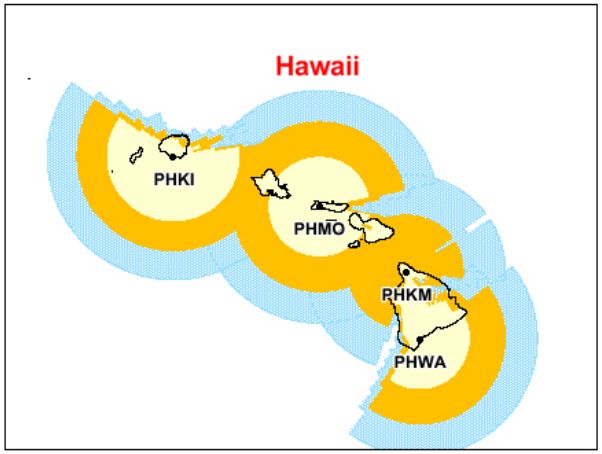
NEXRAD Coverage Below 10,000 Feet AGL











VCP 12 Coverage

- 3,000 ft above ground level*
- 6,000 ft above ground level*
- 10,000 ft above ground level*

*Center of beam height (assuming Standard Atmospheric Refraction)
Terrain Blockage Indicated where 50% or more of beam blocked

OCONUS:
4 DoD Radars
12 FAA Radars (including Puerto Rico)

NEXRAD Program

- Tri-agency Network:
  - 122 owned/maintained by NWS
  - 25 owned/maintained by DoD
  - 12 owned/maintained by FAA

- All WSR-88Ds are critically valuable to all three agencies

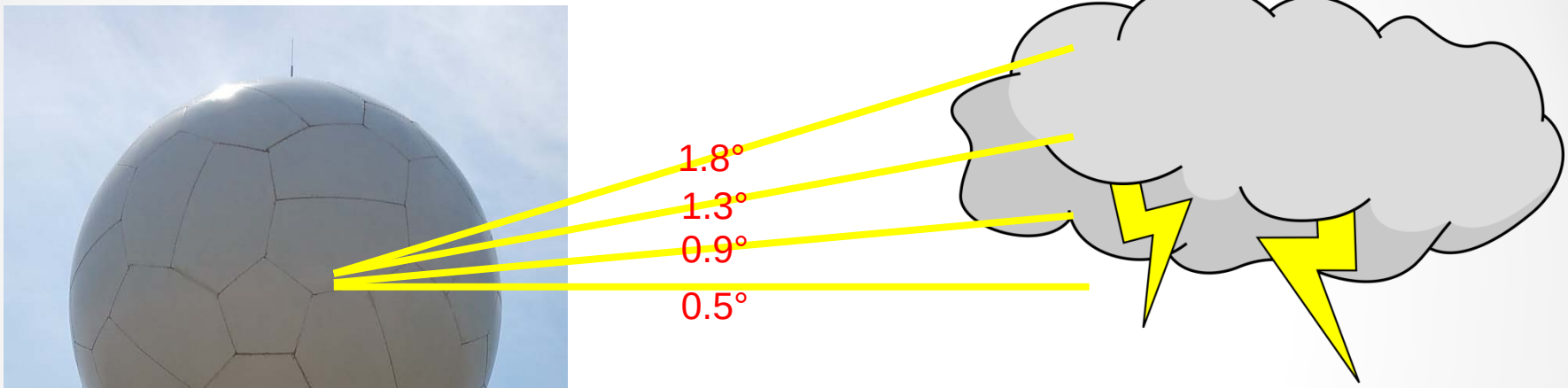
Radar Operations Center

- WSR-88D Life-cycle support
- Tri-agency staffed and funded
- Responsible for wind farm analyses for all WSR-88Ds

Future of NEXRAD

- Dual polarization completed in 2013
- Service Life Extension Program (SLEP)
  - 7-Year (2015-2022), $150M tri-agency investment
  - Keep radars viable into 2030s
  - Signal processor, transmitter, pedestal, equipment shelters
- Next radar system in 2030s? Phased Array?

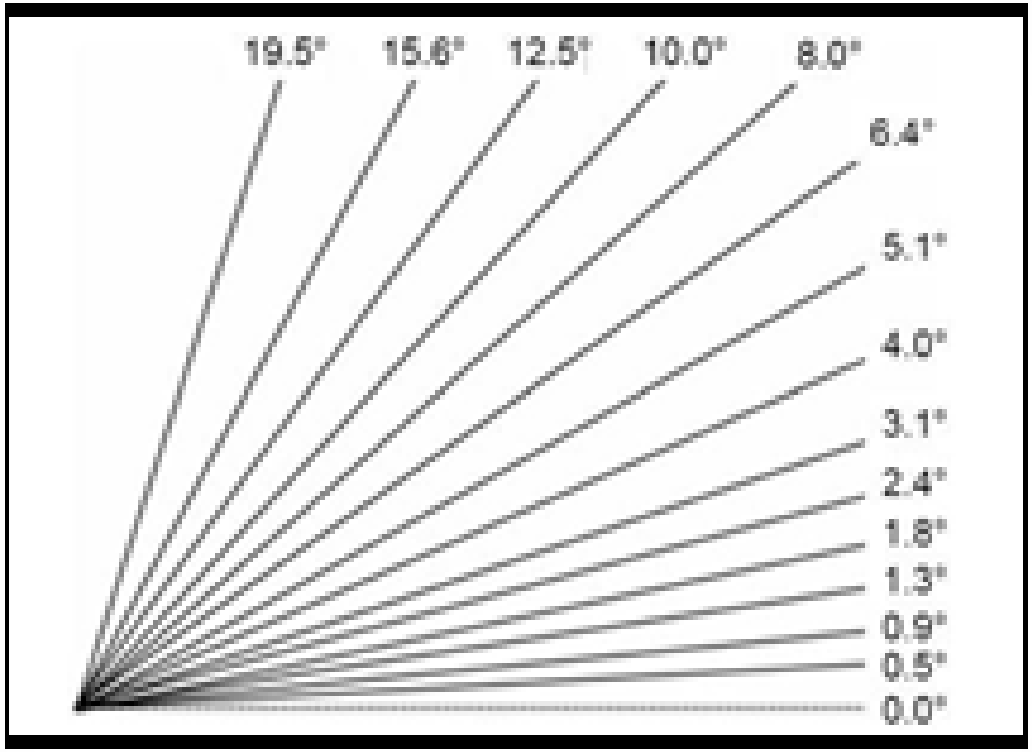
How Does NEXRAD Work?



Radar tilts at multiple elevation angles to scan the atmosphere. In Volume Coverage Pattern (VCP) 12, there are 14 elevation angles.

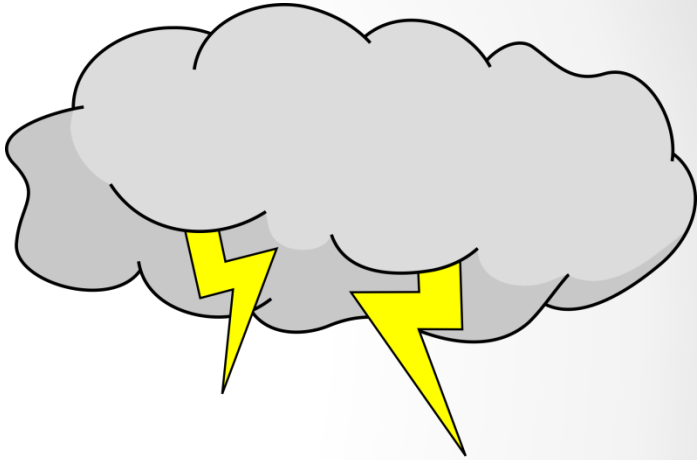
For early detection of hazardous weather, the low angles are the most important, but also the most impacted by wind turbines.

How Does NEXRAD Work?



Most common operation modes during severe weather are VCPs 12 and 212, which scan the atmosphere rapidly. New technology allows scans of the lowest elevation angle every 75-90 seconds. These low level views are critical to detecting tornadoes, high winds/downbursts, wind shifts affecting aviation, and accurate precipitation estimates.

Wind Turbines and Radar



Wind Turbines and Radar

- Wind turbine blades reflect the radar's energy, scattering back toward the radar
  - Gives appearance of "false returns"; looks like severe weather on radar
  - Contaminates low level base data (precipitation, wind) and algorithms (tornado signatures, hail signatures)

- Risk of missed/delayed severe weather warnings, misleading algorithm output, and erroneous precipitation estimates

- Greater the number of low elevation angles contaminated, the greater the risk to the DoD, NWS, FAA missions

Wind Turbines and Radar

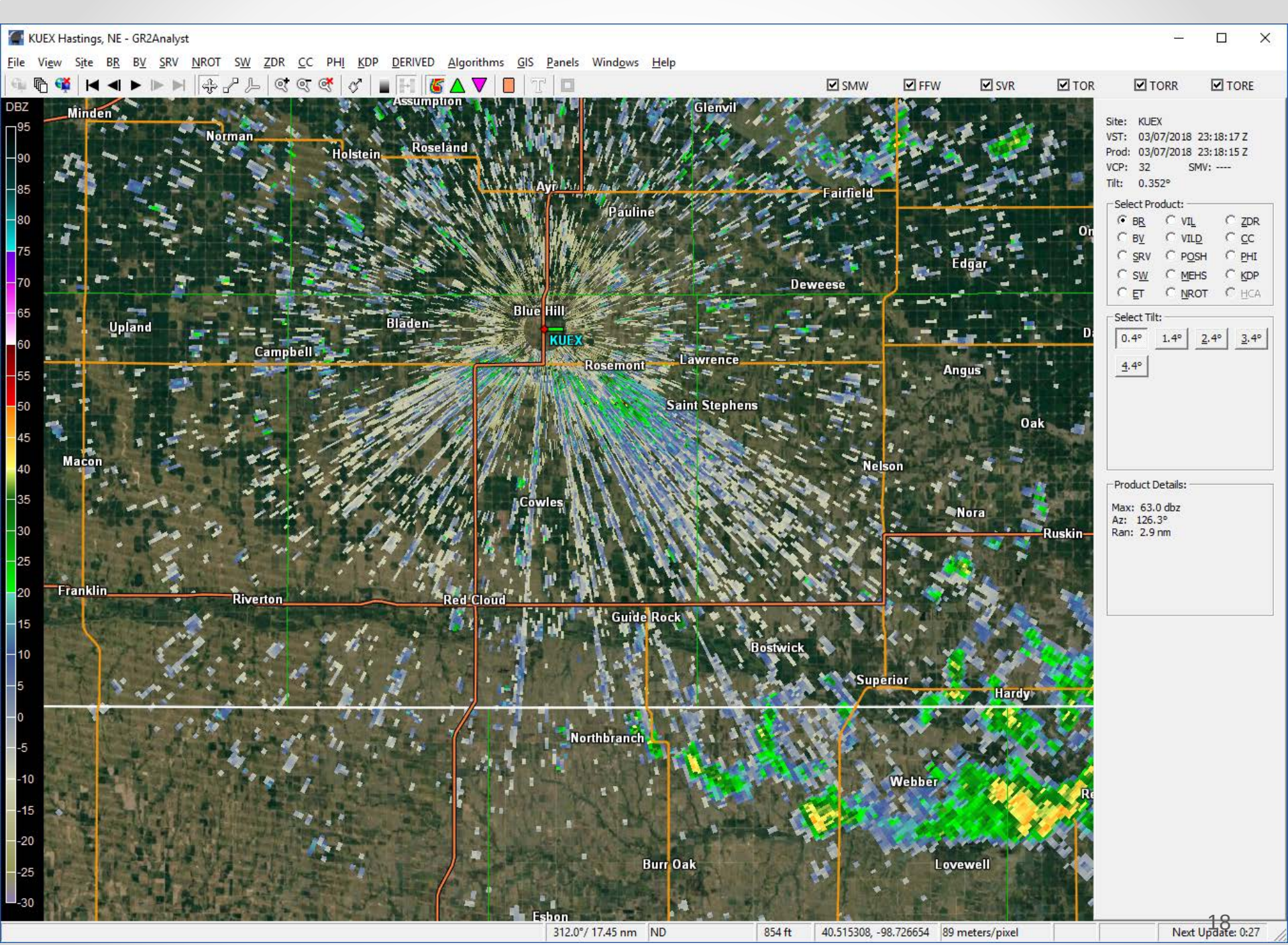
- Wind turbine contamination is a growing problem
  - Since 2008, ROC has analyzed over 1600 projects
  - Increasing with each year:
    - 180 projects Jan 2017-Jan 2018
    - 132 projects Jan 2016-Jan 2017
  - **These are projects we know about!**

- Turbines are getting larger
  - We routinely see proposals for turbine heights 180 – 210 meters
  - This is up from the average of 150 meters five years ago
  - Developers are repowering older projects
    - Reducing number of turbines, but increasing heights
    - For weather radar, any increase in height is an impact to the data regardless if the number of turbines decrease

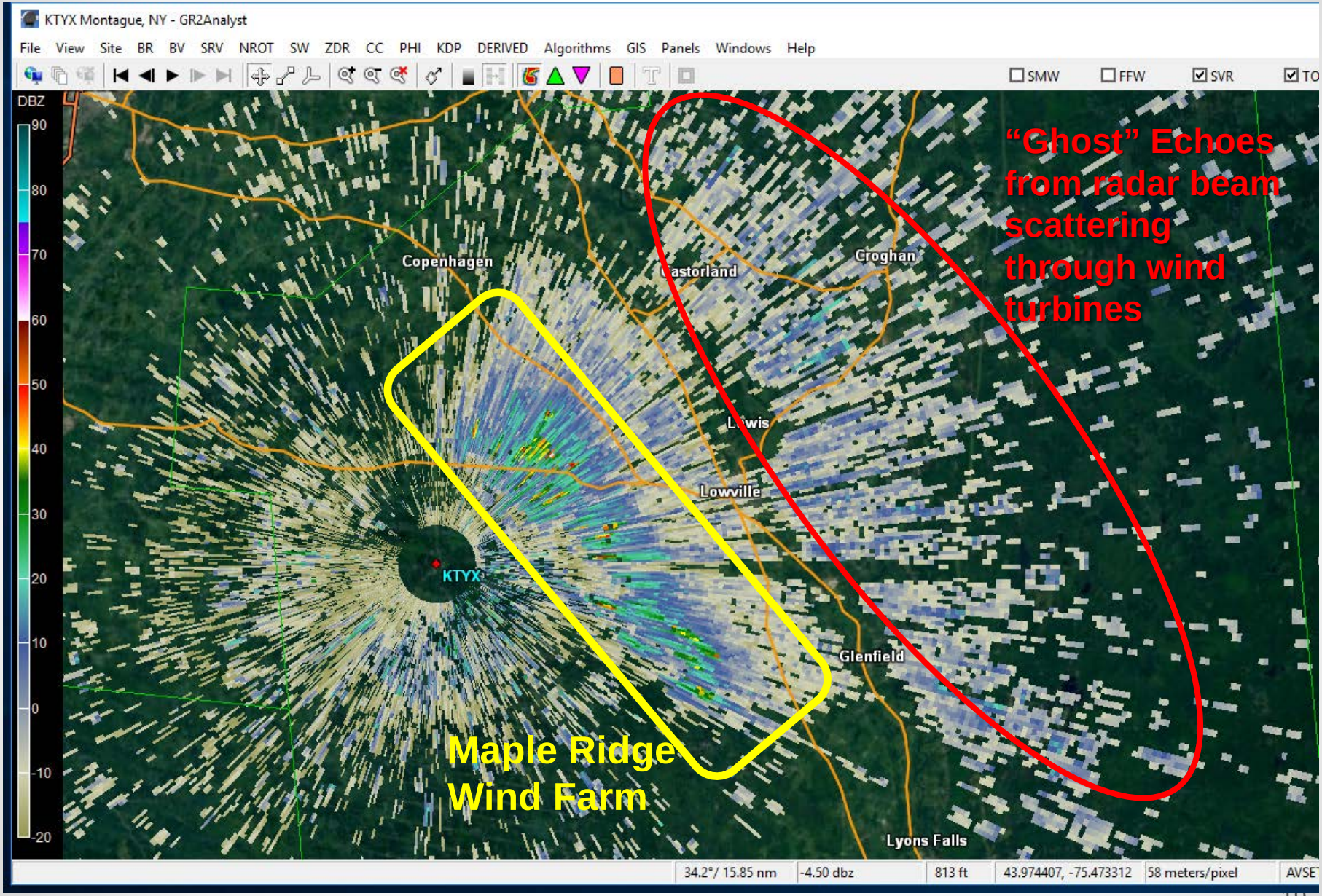
Wind Turbines and Radar

New Wind Farm approx 4 km
from Hastings, NE radar

Wind Turbines and Radar


KUEX Hastings, NE - GR2Analyst
File View Site BR BV SRV NROT SW ZDR CC PHI KDP DERIVED Algorithms GIS Panels Windows Help
SMW FFW SVR TOR TORR TORE
DBZ
95 90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0 -5 -10 -15 -20 -25 -30
Minden
Norman
Holstein
Roseland
Assumption
Glenvil
Ayr
Fairfield
Pauline
Edgar
Deweese
Blue Hill
KUEX
Upland
Bladen
Campbell
Rosemont
Lawrence
Angus
Saint Stephens
Oak
Macon
Nelson
Cowles
Nora
Ruskin
Franklin
Riverton
Red Cloud
Guide Rock
Bostwick
Superior
Hardy
Northbranch
Webber
Burr Oak
Lovewell
Esbon
Site: KUEX
VST: 03/07/2018 23:18:17 Z
Prod: 03/07/2018 23:18:15 Z
VCP: 32 SMV: ----
Tilt: 0.352°
Select Product:
BR VIL ZDR
BV VILD CC
SRV POSH PHI
SW MEHS KDP
ET NROT HCA
Select Tilt:
0.4° 1.4° 2.4° 3.4° 4.4°
Product Details:
Max: 63.0 dbz
Az: 126.3°
Ran: 2.9 nm
312.0°/ 17.45 nm
ND
854 ft
40.515308, -98.726654
89 meters/pixel
Next Update: 0:27

Turbine Contamination appears as Precipitation

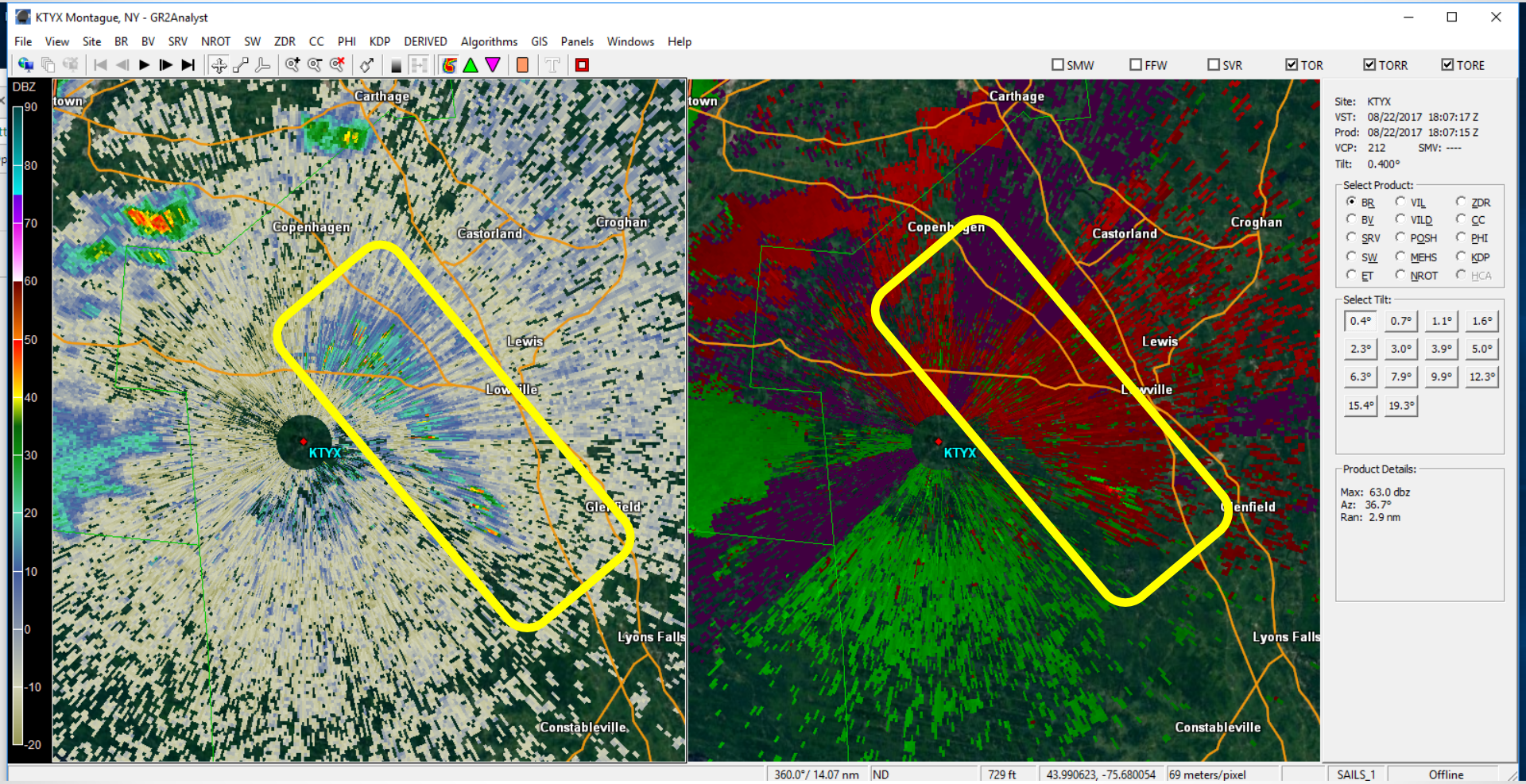


Fort Drum (KTYX): Wind Turbines and Severe Weather

Weather Event: August 22, 2017

18:07 UTC to 19:08 UTC

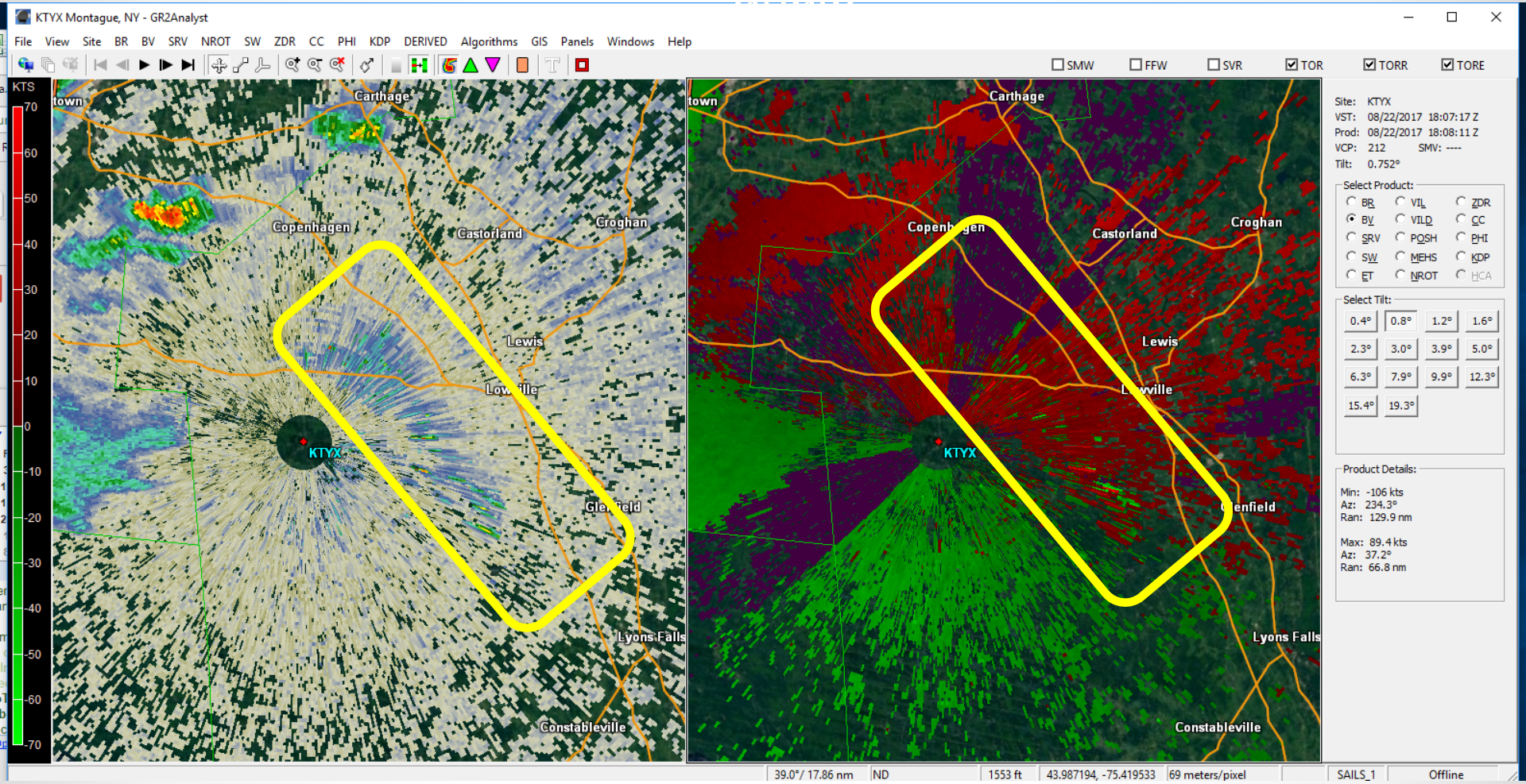
KTYX 8/22/17 18:07 UTC – Lowest elevation angle



Reflectivity

Base Velocity

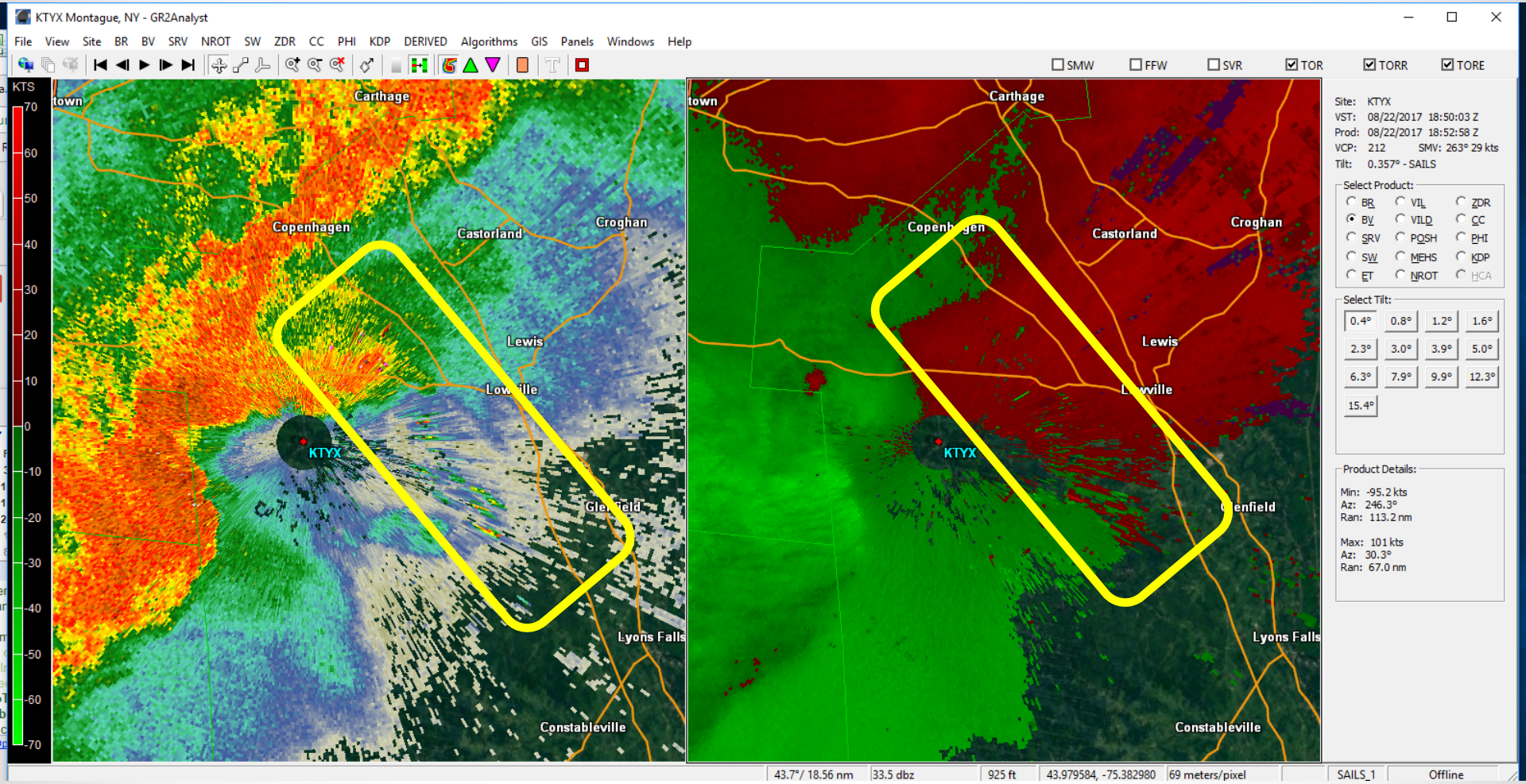
KTYX 8/22/17 18:08 UTC – Second lowest elevation



Reflectivity

Base Velocity

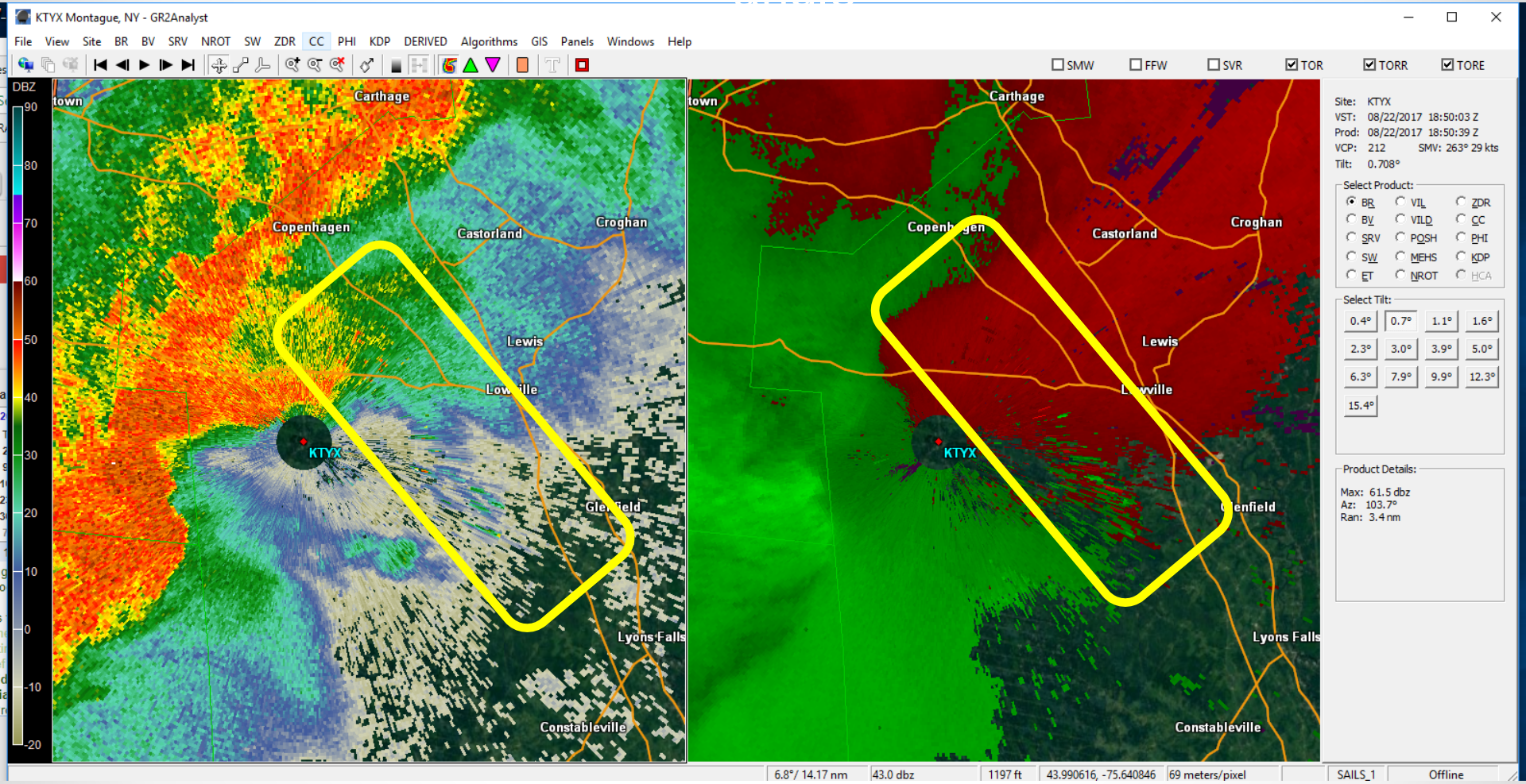
KTYX 8/22/17 18:52 UTC – Lowest elevation angle



Reflectivity

Base Velocity

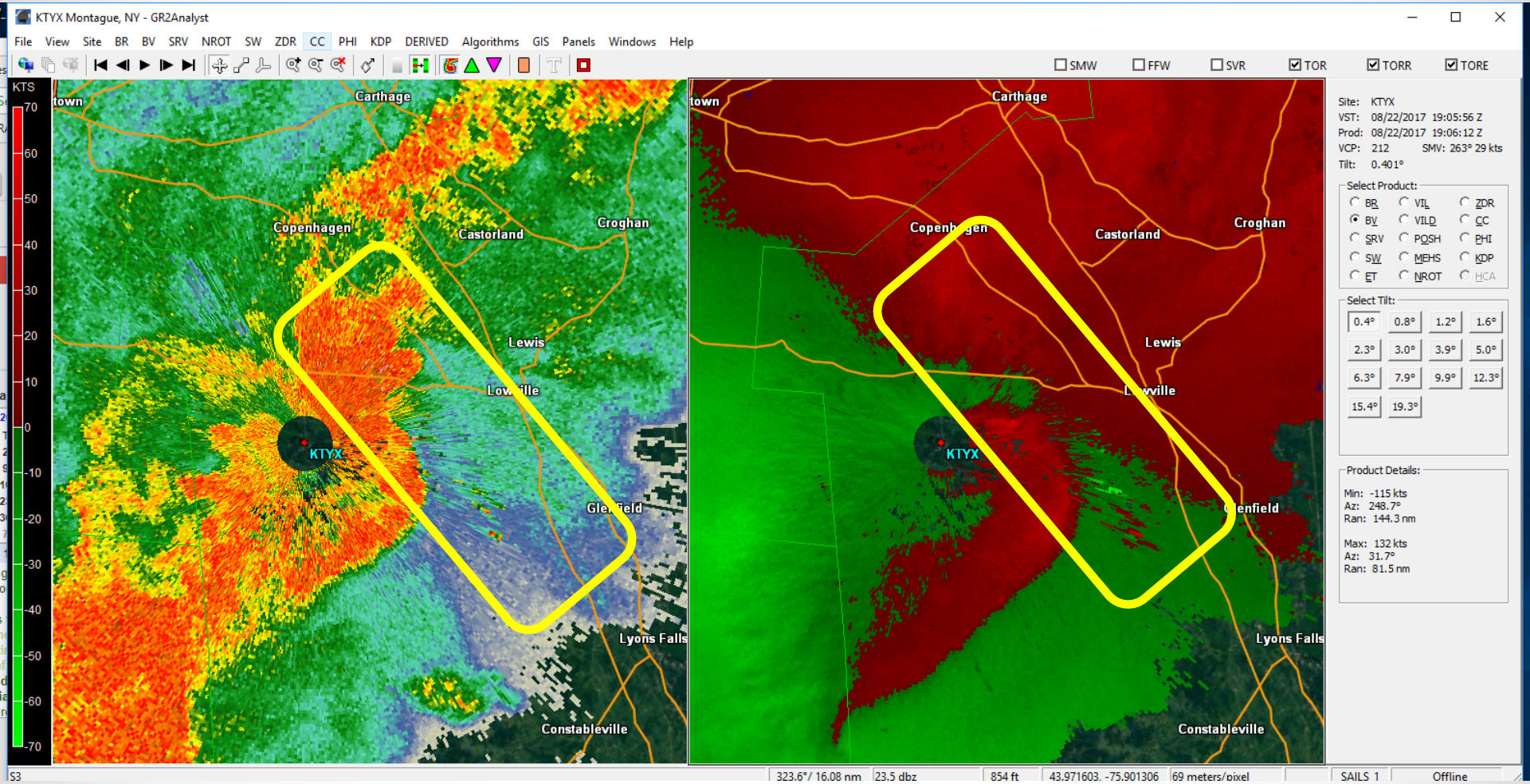
KTYX 8/22/17 18:50 UTC – Second lowest elevation



Reflectivity

Base Velocity

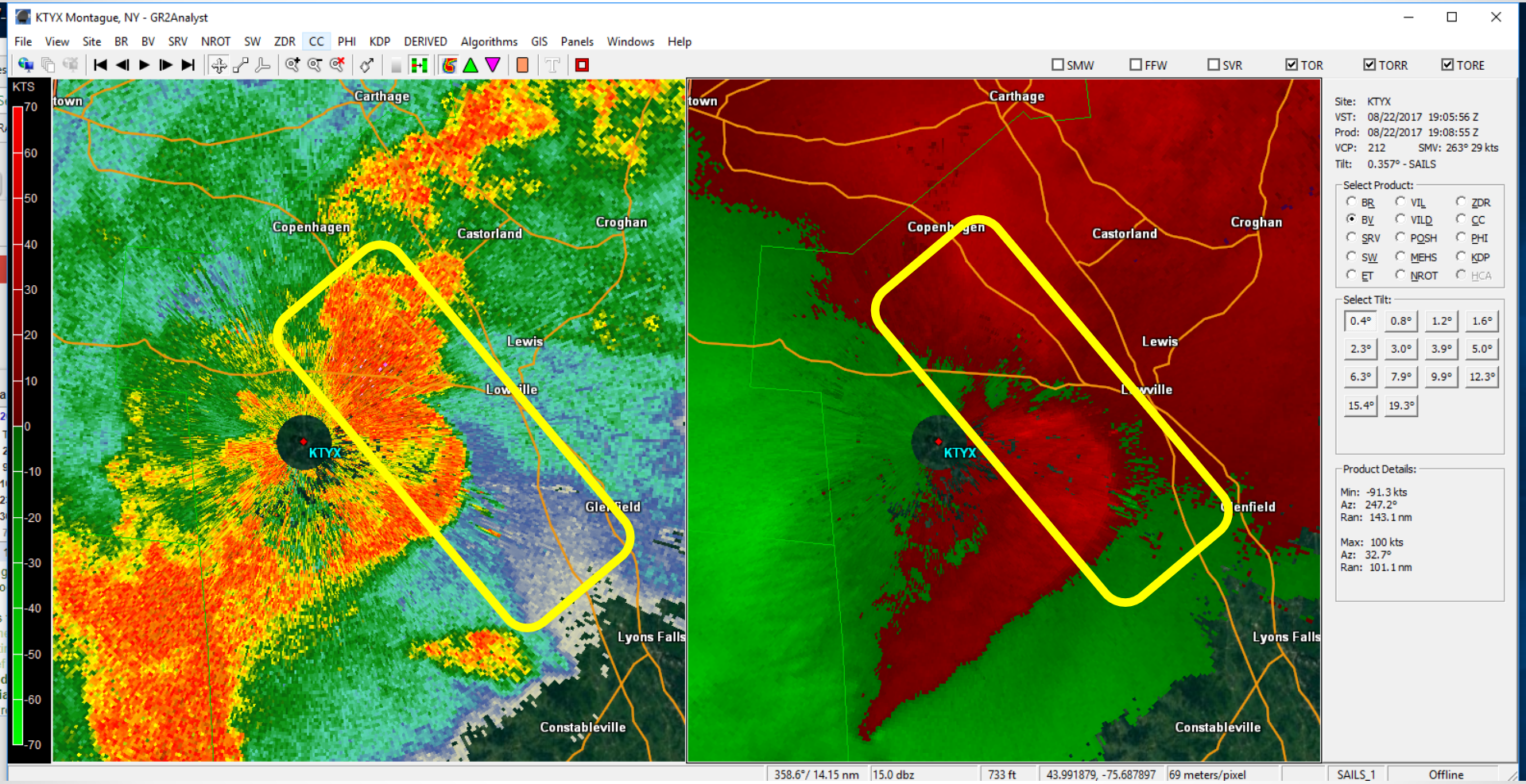
KTYX 8/22/17 19:06 UTC – Lowest elevation angle



Reflectivity

Base Velocity

KTYX 8/22/17 19:08 UTC – Lowest elevation angle



Reflectivity

Base Velocity

ROC Wind Turbine Analysis

- Currently, we find out about proposals through NTIA (National Telecommunications and Information Administration)
  - Developers voluntarily submit proposals through this agency
  - Some proposals are never submitted, so we are unaware

- Occasionally find out about proposals directly from the developer or through concerned local stakeholders

ROC Wind Turbine Analysis

- Distance from radar and terrain is important
  - 4km NO BUILD Zone to protect radar from mechanical damage due to strong returns from turbines
  - Closer turbines generally contaminate more elevation angles, and is dependent on terrain

- We determine how many elevation angles will be contaminated
  - More angles = greater impact
  - Contamination of lowest three angles or more = automatic NO BUILD recommendation
    - Going higher in the atmosphere than three elevation angles greatly diminishes ability to detect severe weather features and significantly reduces accuracy in precipitation estimation

Mitigation and Curtailment

- Mitigation
  - Work with the developer to voluntarily reduce turbine heights, eliminate turbines of greatest concern, move turbines greater distance from radar

- Curtailment
  - Developer agrees to cease operations during periods of hazardous weather
    - Tri-agencies will insist on binding agreement

Other Options?

- Why not move the radar?
  - Temporary fix at best
  - Tri-agencies have siting requirements, which reduces the area where radar could be moved
  - Wind developments at new radar site will put us back in same position

- Can technology fix the problem?
  - Weather radar is different than air traffic
    - No signal processing solution on horizon for weather radar
  - How to remove wind turbines without removing important weak and strong features is unknown
  - International colleagues suffering from same challenges

Other Options?

- Why not add a new, off-the-shelf radar?
  - Would require yearly O&M costs, comms, display
    - High costs (unfunded) for agencies to maintain after initial installation
  - Does not meet same standards as WSR-88D
  - Would be very difficult to integrate 88D software into commercial system
    - Agency required algorithms, products would not be replicated
    - Is not a substitute for reducing 88D capabilities

Working Together

- We must work together and engage early in the process to find the most reasonable solution

Resource

- NEXRAD Screening Tool on Radar Operations Center website is a good first look, but still need ROC analysis
- https://www.roc.noaa.gov/WSR88D/WindFarm/WindFarm.aspx

Questions?

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Thank you for joining today's program.