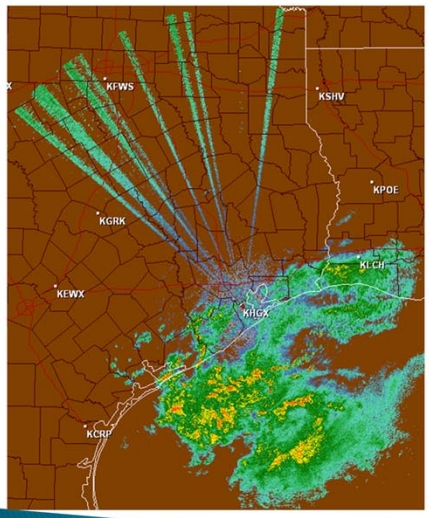


WSR-88D Interference

Radar Operations Center

1

WSR-88D Interference

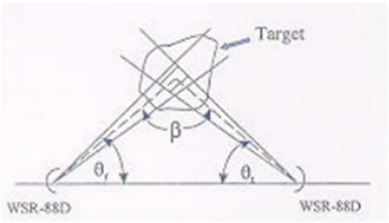
- Types of Interference
  - Bi-Static Coupling
  - Land, air, ship radars
  - Wireless Technologies
  - Process for Resolution
- Wind Turbines
  - Proposals
  - Process for Mitigation
- Tree Blockage
  - Growing Problem
  - Tree Removal Mitigation
  - Mitigation in Precip Estimates

2

This presentation will discuss different types of interference, wind turbine clutter, and tree blockages. The process for resolution and mitigation of these issues, as well as the challenges will be described.

Types of Interference: Bi-Static Coupling

- Adjacent radars with frequencies less than 10 MHz apart sample a common target at the same time, same altitude
- "Spikes" in base data – from one or both radars



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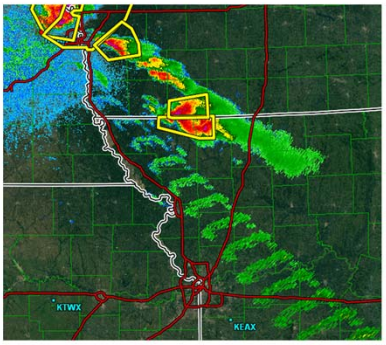
- Common clusters of 88Ds
  - Central U.S.
  - Southeast U.S.
  - Northeast Corridor



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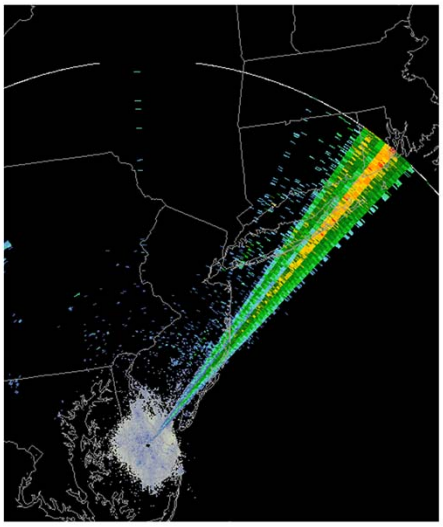
- "Spikes" in base data – from one or both radars
- Sometimes called "Running Rabbits"
- Common clusters of 88Ds
  - Central U.S.
  - Southeast U.S.
  - Northeast Corridor
- Requires a frequency change of one or more radars, which presents other interference risks

Present since installation of WSR-88D



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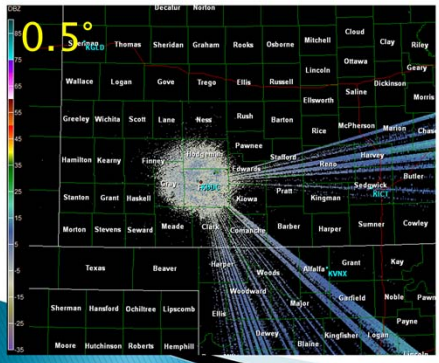
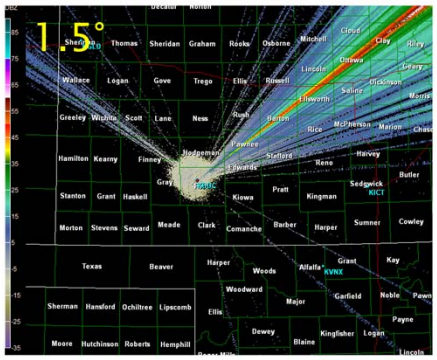
Bi-Static coupling has occurred since the beginning of the WSR-88D. The only way to truly resolve the issue is to change frequencies of one or more of the affected radars. Changing frequencies poses other challenges and the ROC does not support this as a mitigation strategy.

Types of Interference: Land, Air, Ship Radars

- Other radar systems bleed into 88D frequency
- Military, FAA/Navy, commercial
- May last for one volume scan; may be persistent
- May affect multiple elevation angles





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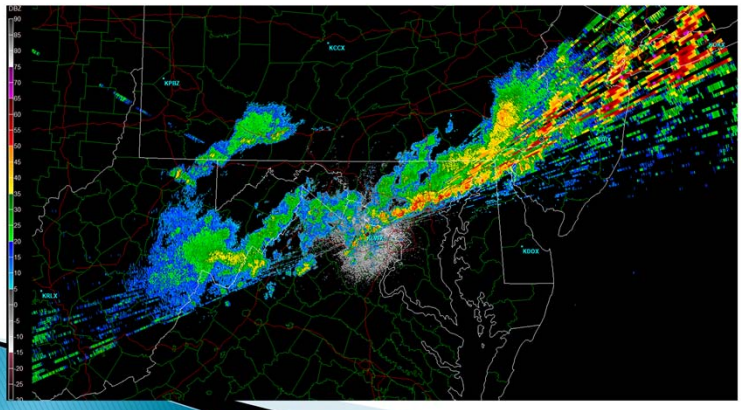
These images depict interference from a radar onboard a military aircraft flying over the Dodge City, KS area. This interference was intermittent and evident on multiple elevation angles.

Types of Interference: Land, Air, Ship Radars

- Difficult to track
  - Intermittent
  - Classified (military) assets
- Increasingly problematic
  - More commercial/public radars (academia, media, community, defense)



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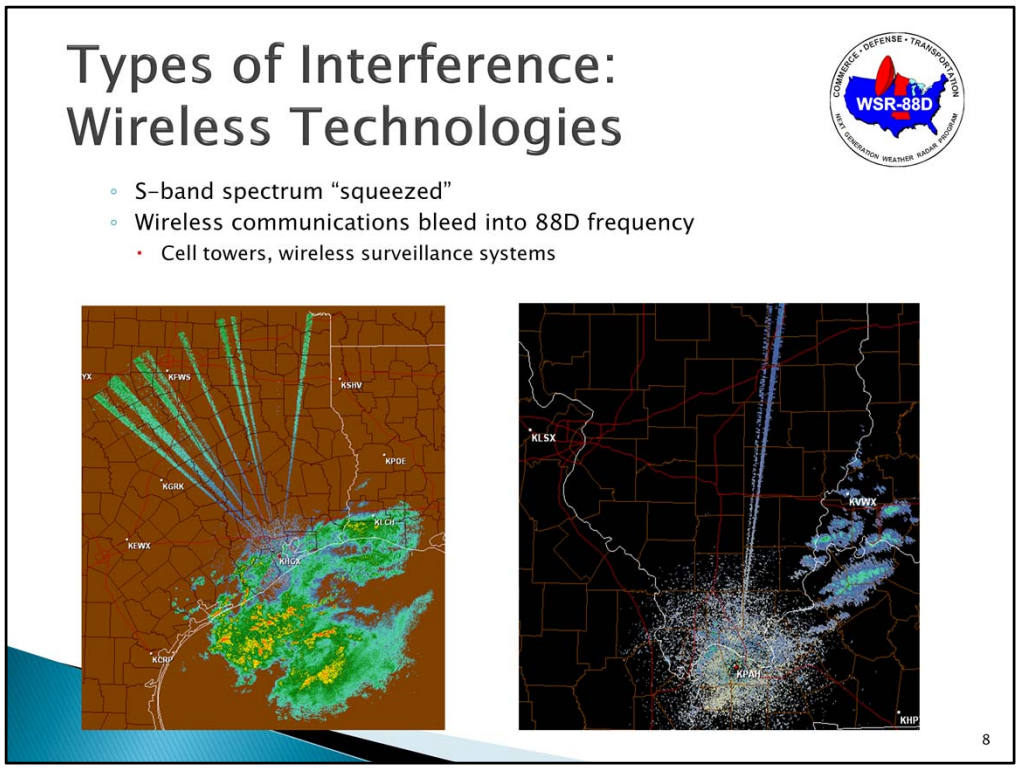
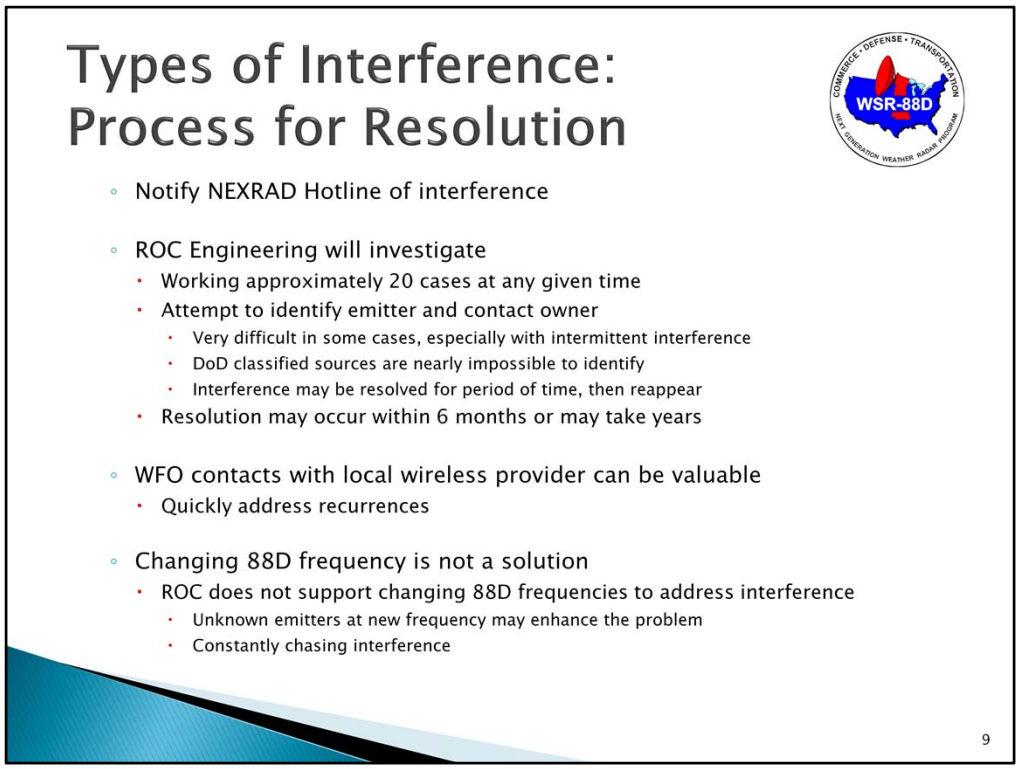


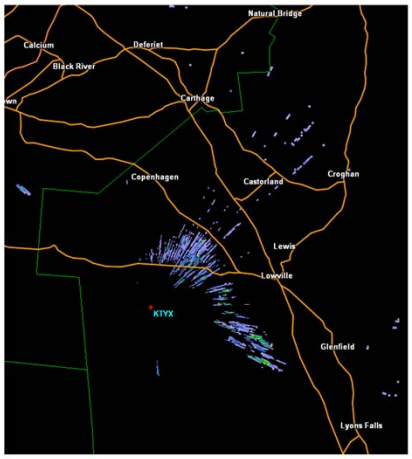
The S-band is becoming increasingly crowded, with many types of systems competing for the same frequencies. Interference from cell phone towers is one of the most common types of interference seen on the WSR-88D, but can be caused by other wireless emitters.



If interference is noted, the first step is to contact the NEXRAD Hotline. ROC Engineering will investigate, but the process can be very slow. The ROC will attempt to identify the source of the interference and may work with other government agencies, such as the FCC, if needed. If the source is a classified national defense system, it is nearly impossible to identify. In some cases, the interference can be resolved quickly, but some situations take months or years to resolve. There are some cases of interference that may never be resolved, especially if the source cannot be identified. Once the ROC takes the lead to initiate contact with a source (such as the owner of a cell tower), the WFOs may be able to more quickly address any interference recurrences locally. For any initial contacts, however, it is strongly recommended to report interference to the Hotline and allow the ROC to engage with the parties. Although changing the radar's frequency could resolve one particular interference issue, there are so many unknown emitters within the S-band that another frequency could be just as problematic.

Wind Turbines: Proposals

- Developers send proposals to NTIA
  - Developer under no obligation to submit proposal for analysis
  - Circulated to NOAA/NWS
  - ROC analyzes proposals for 88D impacts
    - 1,322 since ROC began tracking in 2008
    - 114 since Jan 2015
- Turbines becoming taller
- Not just a central plains issue
  - Becoming more common in the east and west



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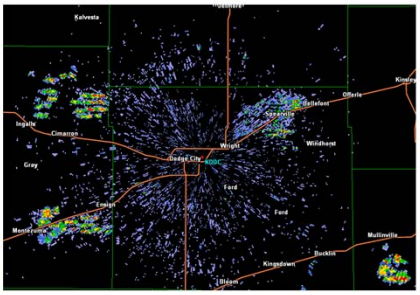
Wind energy developers, on a voluntary basis, send wind farm proposals to the NTIA (National Telecommunications and Information Administration), who then routes the proposal through multiple agencies (including NOAA/NWS) for analysis. Trends seen by the ROC include increasing heights of wind turbines and more energy developments in the western and eastern U.S.

Wind Turbines: Process for Mitigation

- 4 km No-Build Zone
  - No legal authority
  - NWS can only suggest recommendations to developers
  - NWS requests mitigation when turbines enter 0.9° cut
- Can implement Curtailment Agreements with developers
  - Stops operation during severe weather
  - Data sharing agreement
  - Parties not bound to agreement
- No signal processing solution on horizon
  - Same challenges experienced by Canadians, British, and Germans
  - ROC serving as NWS representative on multi-agency (DOE, DOT, DoD) Wind Turbine Working Group

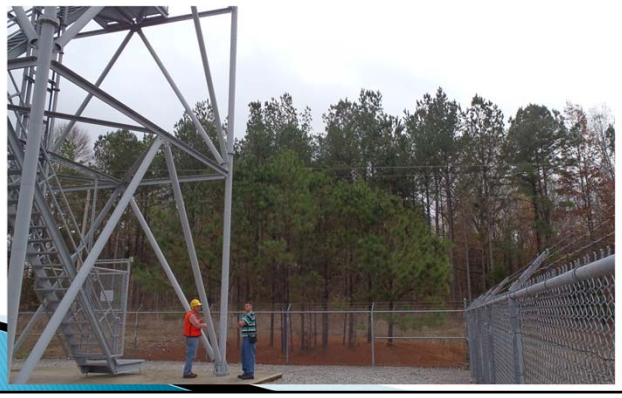


11

The ROC recently expanded the No-Build Zone from 3 km to 4 km away from the radar, but developers are under no legal obligation to comply. The ROC can suggest mitigation strategies, such as ceasing operations while a severe storm passes nearby or sharing turbine data with the local WFO, but those strategies are voluntary. There is currently no signal processing strategy available to remove wind turbine clutter from the base data, while not losing important, weaker radar signatures (e.g. gust fronts). Our international partners also share some of the same challenges. The ROC serves on a working group with other government agencies to discuss best practices and share knowledge related to wind turbine clutter and mitigation.

Tree Blockage: Growing Problem

- 20 years of tree growth
- Tower heights vary from 10m to 30m
  - Height chosen to provide best coverage at lowest level possible
  - Taller towers result in more sidelobes
- Trees are not the only obstructions: water towers, cell towers, powerpoles, etc



12

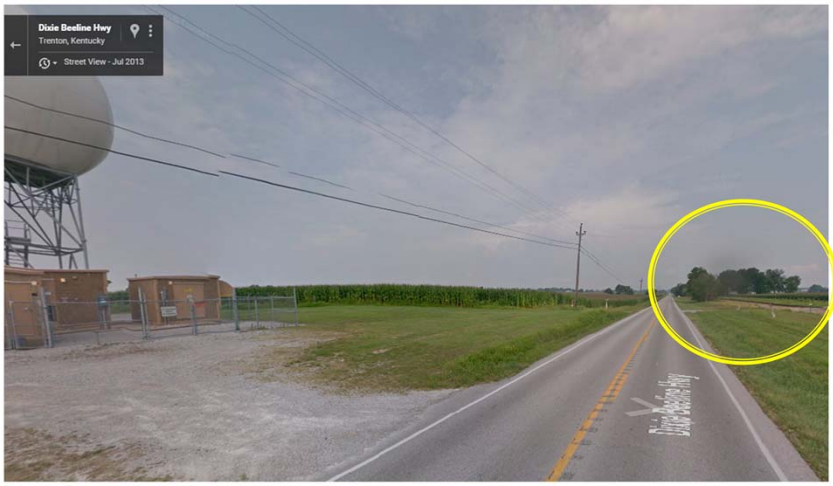
After 20 years, tree growth is an increasing problem, especially in the eastern half of the country. Taller towers can result in more sidelobes and resultant clutter. All radars have sidelobes, but the taller the tower, the more these signals spread out and highlight ground clutter. This change would be most dramatic moving from a 10 meter to 30 meter tower. There are other man-made obstructions blocking radars, including water towers and powerpoles. The image shows trees causing blockage in 2015 at KGWX (Columbus, MS).

Tree Blockage: Growing Problem

13

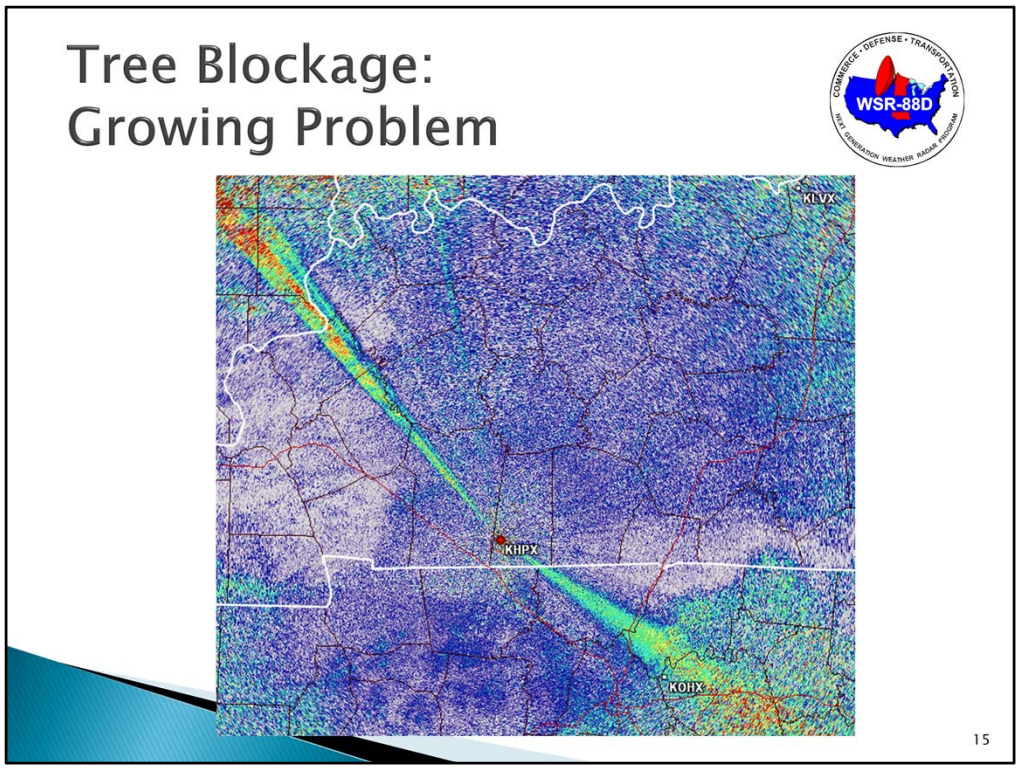
Here is an image from KHPX (Ft. Campbell, KY) from 2013. Note the trees directly next to the radar. It only takes a few trees to cause beam blockage.

Tree Blockage: Growing Problem

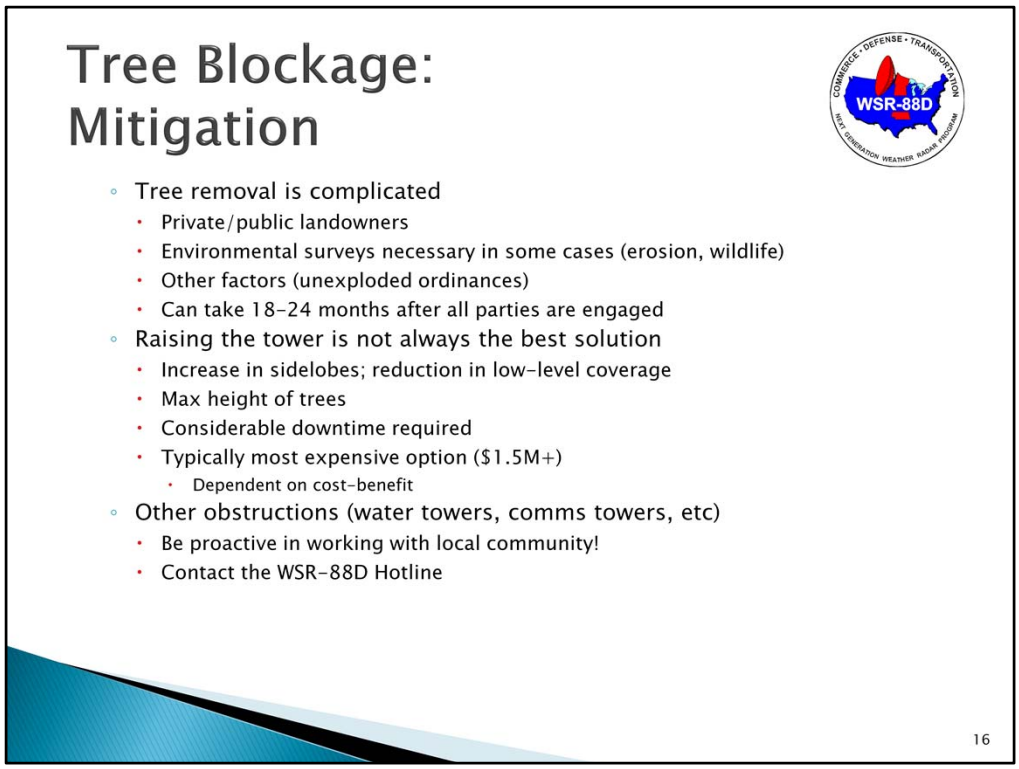


14

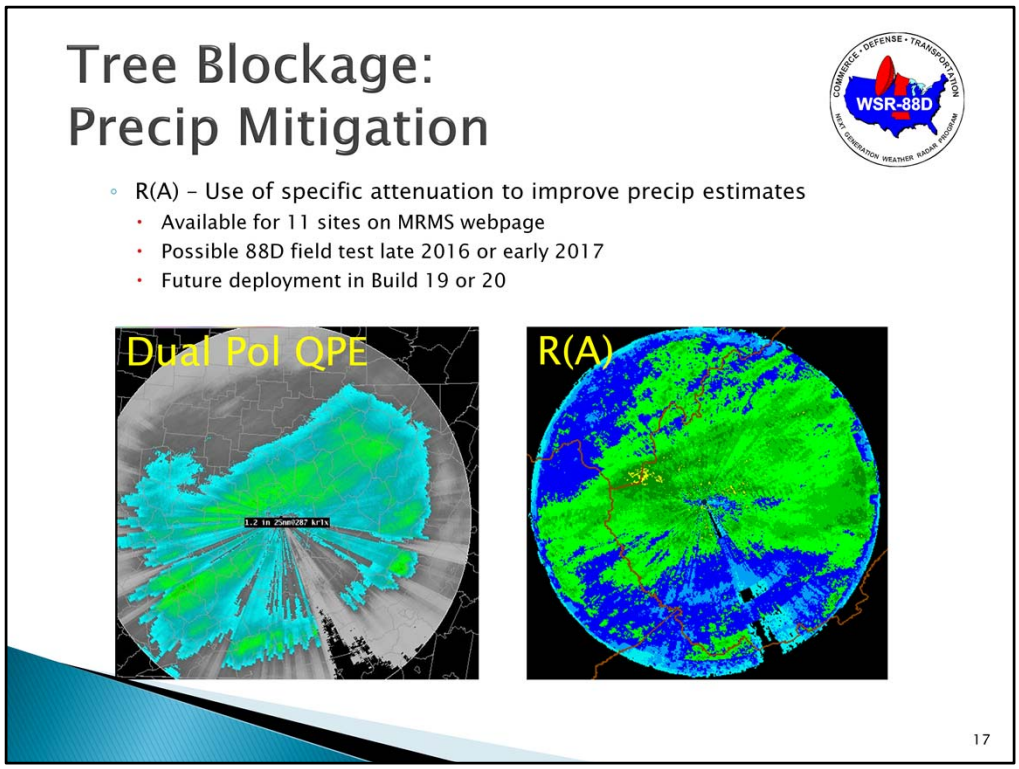
Another view from near KHPX. There is a ridge in the distance with a grove of trees. Those are also sufficient to cause beam blockage.



Here is the ZDR image from KHPX, showing the two regions of beam blockage as wedges of higher ZDR.



If WFOs hear about plans to build new obstructions (water towers, comms towers, etc) near the radar, contact the Hotline so that we might investigate and engage with the local community.



A new rainfall estimation algorithm under development is called R(A), which uses specific attenuation. Currently, this algorithm is running on the MRMS development website for 11 radars. It is not operational. A field test is possible in late 2016 or early 2017, with full deployment in 2-3 years. The image on the left is dual pol QPE from AWIPS for KRLX. The image on the right is for a slightly different time frame from the same event, but is R(A) from MRMS. Note a substantial improvement in the areas of partial beam blockage around the southern half of the area. Regions of full beam blockage are not improved by R(A).

Summary

- Interference is here to stay and will likely increase over time
  - Increased "squeezing" of S-band
  - ROC continues to investigate future improvements
  - ROC working ~20 issues at any time
- Wind Energy
  - Constant development
  - Taller turbines
  - No signal processing solution at this time
  - ROC continues analysis; will notify Regions & WFOs of major impacts
- Trees
  - ROC actively addressing blockages
  - R(A) is promising for precip estimates in areas of partial beam blockage
- Addressing interference and blockages is a long, slow process