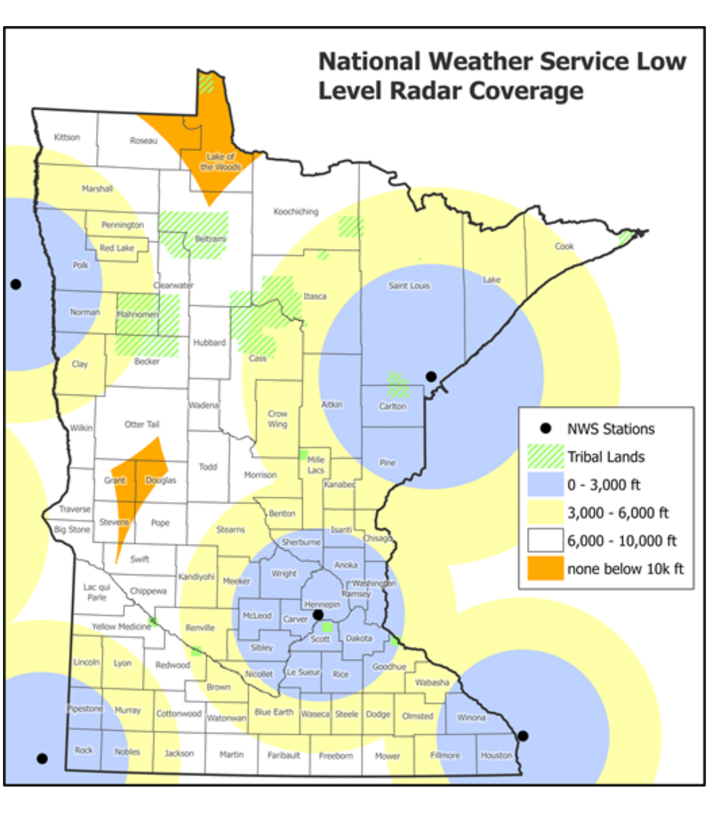
Minnesota's Radar Gaps:

What are they and how they impact Minnesota.

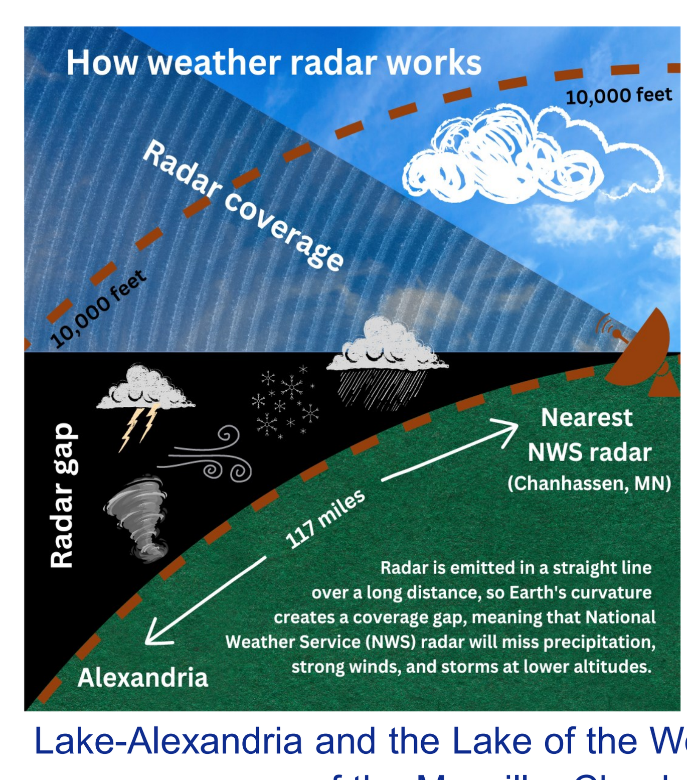
An informational publication by AMEM.

NEXRAD RADAR NETWORK



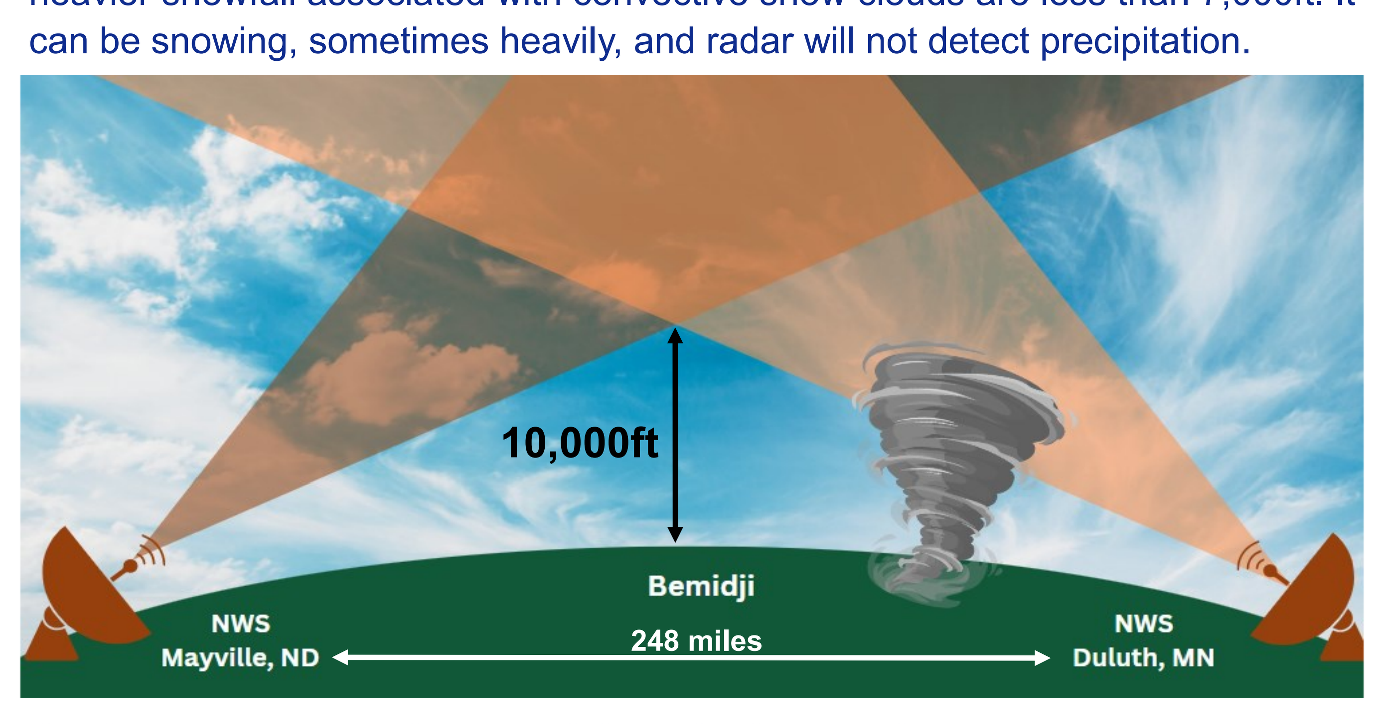
Minnesota is served by six National Weather Service Offices in four different states: Chanhassen, Duluth, La Crosse (WI), Grand Forks (ND), Aberdeen (SD) and Sioux Falls (SD). These local forecast offices work closely with the Emergency Managers in Minnesota. The distance between radar locations means that the further you are from a radar, the less accurate radar coverage becomes. Depending on the season, this can result in undetected snowfall and diminished severe weather detection, including strong surface winds or tornadoes. These concerns led to the development of the AMEM Weather Radar Gap Committee to strategize mitigation solutions as well as educate our members and the public on the implications of radar gap concerns and how they consume the data.

The image above depicts distance rings from each radar site at the height the radar beams are capable of detecting storm activity. The blue ring depicts radar coverage below 3,000ft, the yellow ring shows where radar is able to reach 3,000-6,000ft. Areas above 6,000ft miss most storm features because the radar beam is too high. The white ring shows existing radar capability in 6,000-10,000ft while the orange areas over north central Minnesota and west central Minnesota lack radar coverage below 10,000ft! While the existing radar network provides good mid-level and upper-level coverage, large portions of Minnesota are missing lower level coverage where average Minnesota storm bases are 1,000-3,000ft. Even in areas where there is radar coverage below 6,000ft, additional radar coverage would enhance the clarity of radar. Kandiyohi County for example, is on the edge of coverage below 6,000ft on the eastern side of the county, but above 6,000ft in the west. This is the area a First Responder was killed by a tornado when storm spotting in 2022. Better radar coverage may not have had an impact on the outcome, but would have provided better indication of what was happening closer to the ground, influencing the decision process.

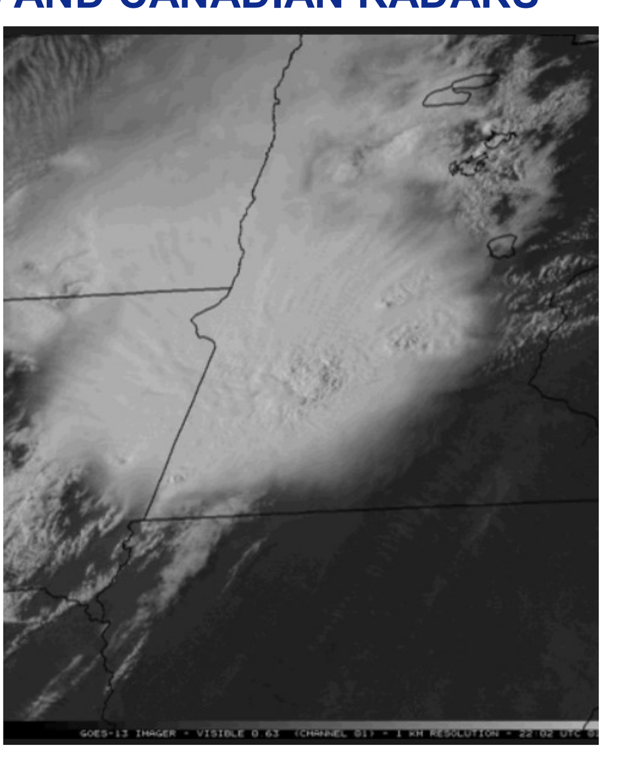


HOW WEATHER RADAR WORKS

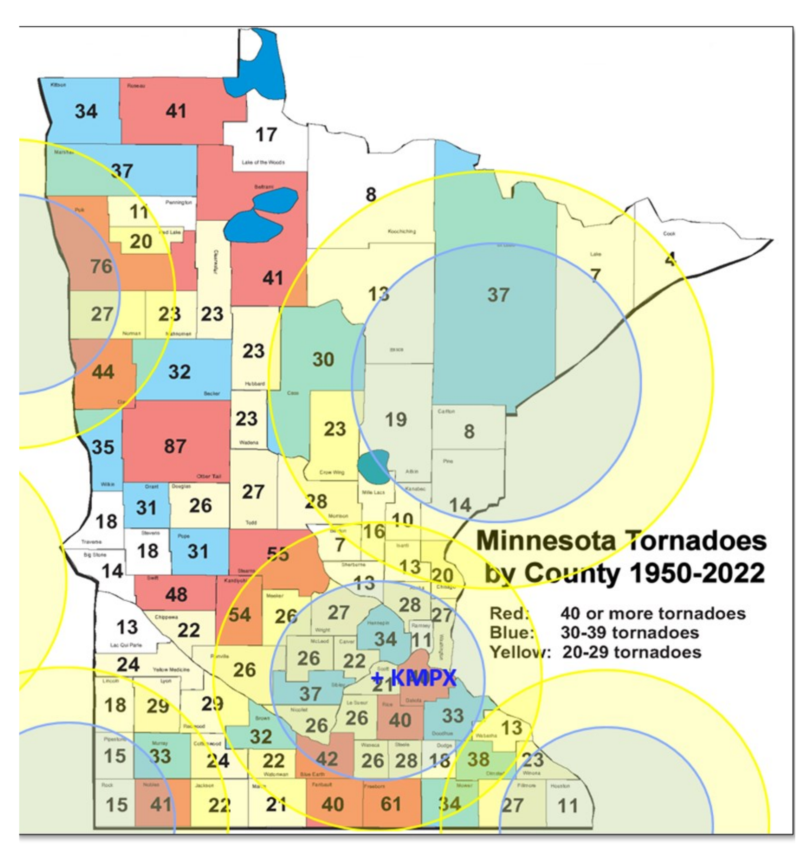
Because radar is emitted in a straight line over a long distance, the Earth's curvature creates a coverage gap in which the radar misses storms at lower altitudes. For example, Bemidji is located about as far away from a radar as you can get in Minnesota, located between Duluth's radar and the radar at Mayville, a distance of 248 miles! This lack of coverage has led to significant public safety issues: in the early hours of July 4th, 2018 an EF1 tornado struck the city with literally no warning. The Elbow Lake-Alexandria and the Lake of the Woods Region are well outside the optimal coverage zones of the Mayville, Chanhassen, Duluth and Aberdeen radars. The radar gap can also create issues during the winter months, when few winter weather related cloud features are detected more than 80 miles from a radar. Most snowfall is associated with low level clouds, often below 4,000ft. Even heavier snowfall associated with convective snow clouds are less than 7,000ft. It can be snowing, sometimes heavily, and radar will not detect precipitation.



GROUND TRUTH, OTHER SOURCES AND CANADIAN RADARS

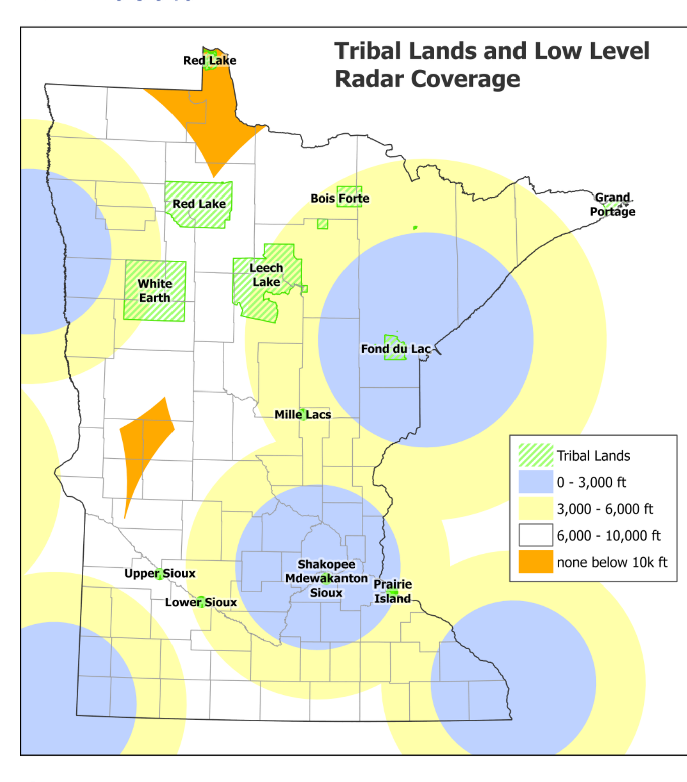


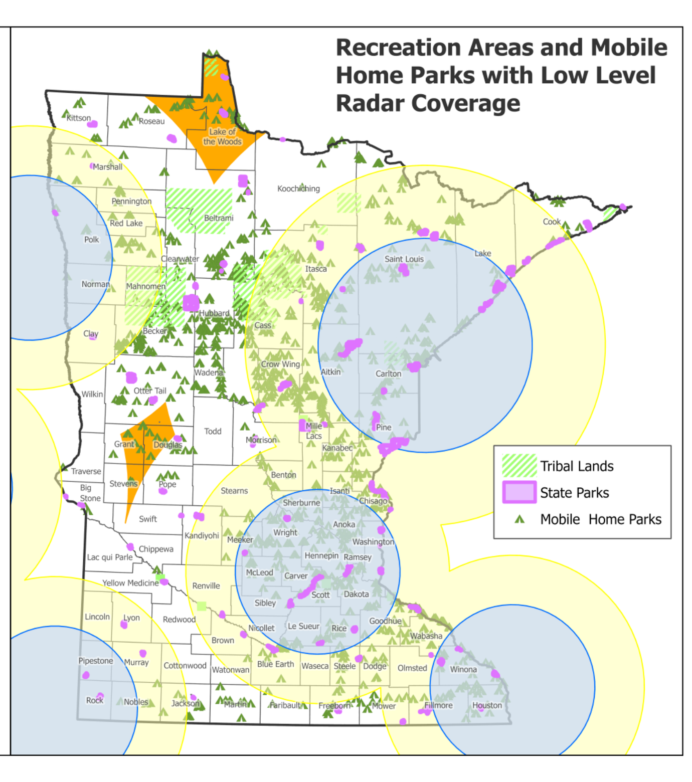
Your average phone/device radar app does not depict all data the National Weather Service has access to. Radar users should be cautiously aware that just because the radar image you are looking at doesn't appear to show anything, you may need to seek shelter. If you are not a trained spotter, sign up for a Skywarn class and report what you are seeing to the National Weather Service. In any weather event, ground truth is important to validate what radar is indicating. Ground truth is verification of what is occurring at ground level. This can be a combination of weather observers, remote observation stations/sensors and cameras. The National Weather Service can utilize a number of sources and tools to get ground truth. Sometimes that can be their office contacting local first responders or Emergency Communications Centers (911), activating Skywarn spotters, airport weather observation stations and MNDOT road sensors. Satellite imagery can also show overshooting tops and storm movement. The National Weather Service also has access to Canadian radars to help provide coverage to border areas, but those radars are well into Canada.



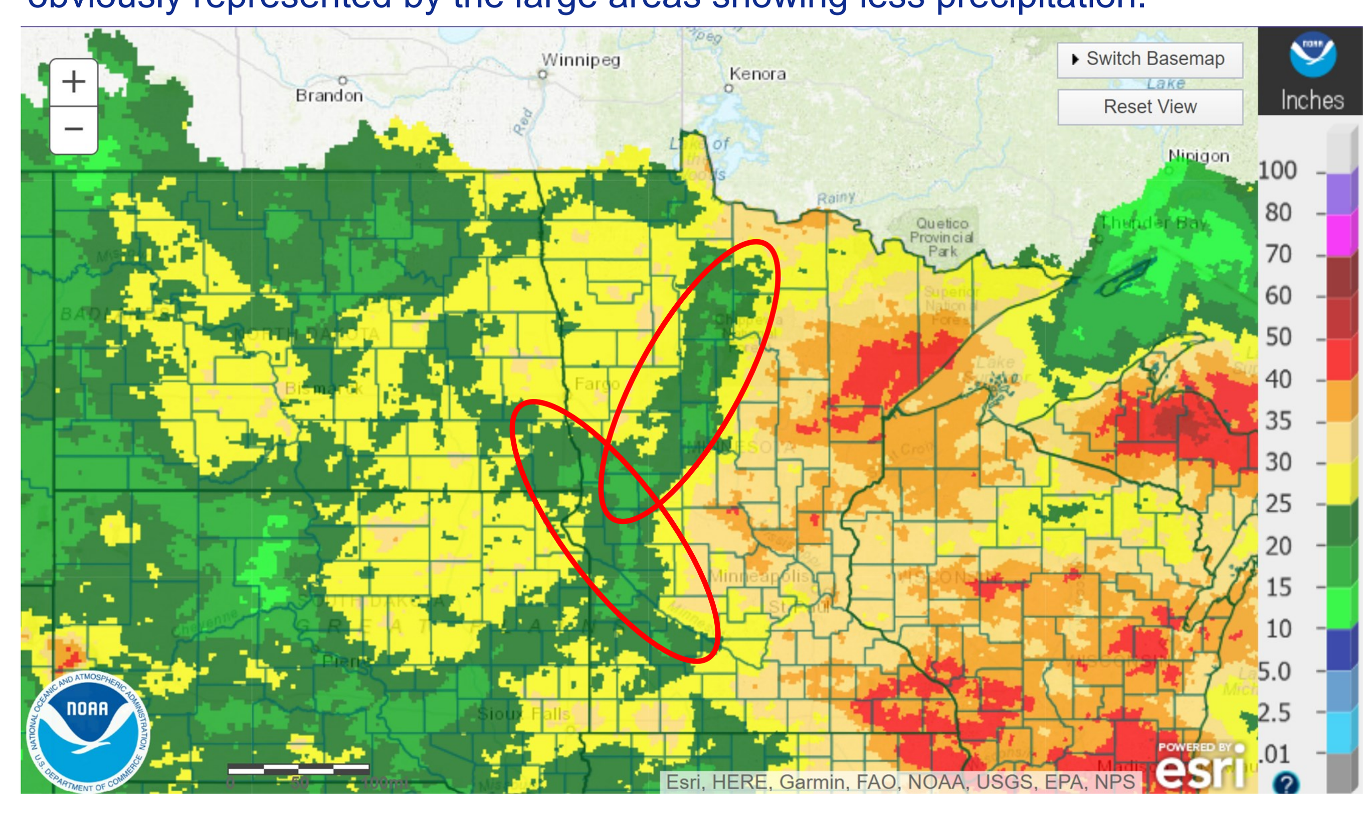
WHY IS THIS IMPORTANT?

The National Weather Service does amazing work forecasting and issuing tornado and severe thunderstorm warnings based off the tools and resources they have available. Large supercell storms are well detected by existing radars, but most tornadoes in Minnesota are not violent EF3+ tornadoes, in fact the vast majority of tornadoes are rated EF2 or lower. Without warning or adequate shelter, even these weaker tornadoes can be life-threatening and dangerous. Many counties in Minnesota see their population double or triple during the summer months as Minnesotans flock to their favorite lake or recreation area. The simplified map above represents existing radar coverage at 6,000ft and below in the blue ring. Many counties that are categorized as red based on frequency of tornadoes are on the edge or within the radar gap below 6,000ft - and are also some of Minnesota's popular summer destinations. The map below left indicates that well over half of Minnesota's tribal lands are impacted by the radar gap. The map below right shows where Minnesota's Park and Recreation Areas are. *It is important to note that private and municipal parks and recreations areas are not represented and there would be significantly more concentration in west central Minnesota.*



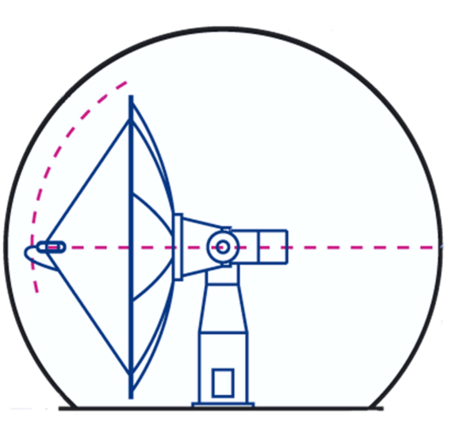


In addition to detecting severe weather, radar provides an estimate on precipitation totals. This can be important for life safety in the issuance of flash flood warnings as they can be triggered based on radar-estimated precipitation. Precipitation also has other impacts for radar data users including farmers and agricultural partners. The map below shows radar estimates for precipitation from February 22nd, 2022 through February 19th, 2023. The radar gap is obviously represented by the large areas showing less precipitation.



MITIGATING AND FILLING THE GAP

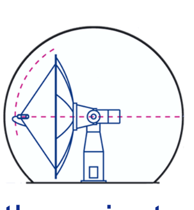
The intent of the AMEM Radar Gap Committee is to help provide additional low-level radar coverage and higher resolution information for National Weather Service and broadcast meteorologist, emergency managers and public safety officials, plus all of our less well-covered but highly storm-impacted, mainly rural communities. This supplemental radar data can assist in the detection of severe weather and tornadoes, provide better precipitation estimates, capture winter precipitation and improve life safety with clearer radar imagery further from existing radars.



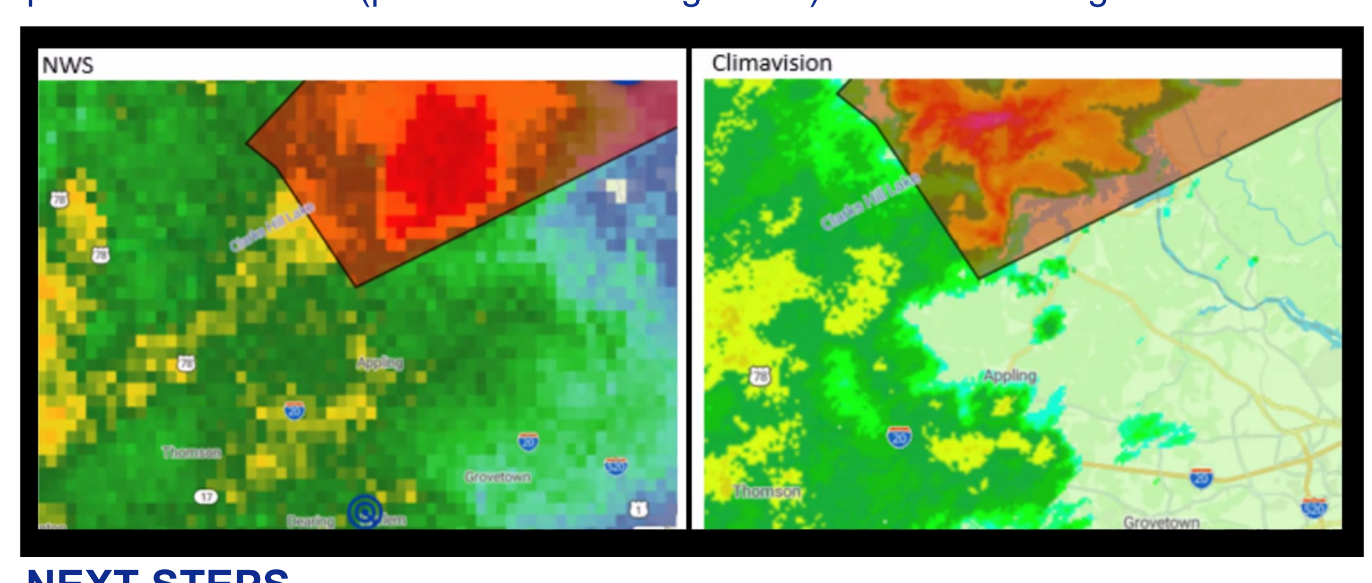
There are a couple of options when it comes to filling the radar gap without reduction in quality, all would require the deployment of additional radars. The NEXRAD radars used today are high-power S-Band radars and are very large with a 28' diameter dish. A couple of these high-performance radars would fill much of the gap in Minnesota, however there are no plans to deploy additional high-power S-Band radars. One option the AMEM Radar Gap Committee explored was to seek funding and partnership with a state agency to deploy smaller mid-power C-Band radars, that have a 14' dish, at several locations across the state. Working with a Consulting Meteorologist with decades of radar experience, the committee determined that six mid-power radars would fill almost all the radar gap areas of Minnesota. Alternatives were also explored with fewer sites, but at the expense of still having some gaps. Regardless, such an endeavor is likely to take years to accomplish and other alternatives have been explored. One option already in development is working with the private sector in fielding some low-power X-Band radars.

PUBLIC-PRIVATE PARTNERSHIP

The tragic death of the First Responder in Kandiyohi County was a call to action for the Emergency Managers serving the populations located in the radar gap. Knowing how supplemental radar data could have improved situational awareness, conversations began on what to do. Those conversations eventually led to the establishment of the AMEM Radar Gap Committee. Since then, many discussions and proposals have been discussed and researched. One public-private partnership that continues to move forward is counties working with the company Climavision. Branding themselves as rebuilding climate technology from the ground up to help businesses and communities mitigate risk, they are about to have their first presence in Minnesota. Deploying low-power X-Band radars in the middle of the radar gap, soon supplemental data will be available.

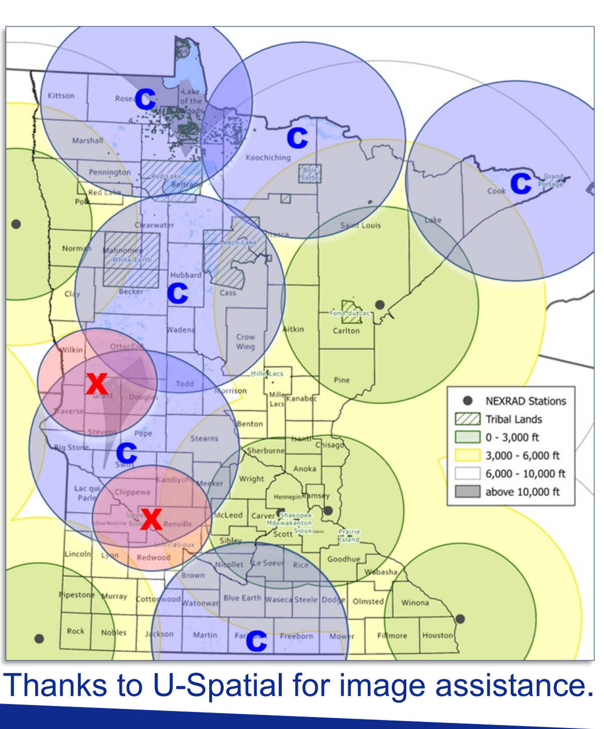


With a smaller dish of a diameter of eight feet, the low-power X-Band radars can be fairly versatile with their deployment. Many water towers and existing taller structures are suitable for mounting of the radar versus a stand alone tower structure which is where the private-public partnership comes into play. Two locations in Minnesota are being finalized for the deployment of Climavision radars, ultimately eight are expected be deployed. The Minnesota locations being finalized are in Renville and Grant Counties. Low-power X-Band radars have some limitations, but can still improve radar coverage in many scenarios. One limitation is radar attenuation, the radar's ability to see through the preliminary storm. Besides having a much larger overall coverage area, larger and more powerful C-Band radars can penetrate through the first storm and detect additional strong to severe storms beyond the first storm. With the deployment of multiple new radars in combination with existing radar data, the radar gap can be significantly reduced, giving all of us a much better picture of what each storm is actually doing. The example below left is a NEXRAD S-Band radar 100-115 miles from the storm, while the Climavision radar, 17 miles from the storm, shows a clearer image and possible hook-echo (possible tornado signature) in eastern Georgia.



NEXT STEPS

While there is more work to be done before we can claim that we have filled the radar gap with supplemental radar data, we are making progress! The map to the right depicts suggested C-Band (blue circle) radar locations and the *proposed* Climavision X-Band radar locations (red circles). Other considerations we are working on are data access and integration, more public-private partnerships and finding a state agency that could collaborate on this project. Our main objective is education and the safety of our communities.



Thanks to U-Spatial for image assistance.

AMEM RADAR GAP COMMITTEE

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