IMPACTS OF SUPER-RESOLUTION DATA ON NATIONAL WEATHER SERVICE WARNING DECISION MAKING

Jonathan M. Vogel

National Weather Center Research Experiences for Undergraduates,
University of Oklahoma, Norman, Oklahoma
and
The Pennsylvania State University, University Park, Pennsylvania

Clark Payne, Cynthia A. Van Den Broeke, and Leslie R. Lemon

Cooperative Institute for Mesoscale Meteorological Studies
and
National Oceanic and Atmospheric Administration's Warning Decision Training Branch,
University of Oklahoma, Norman, Oklahoma

ABSTRACT

Super-resolution data provided by the Weather Surveillance Radar-1988 Doppler (WSR-88D) has changed the look and feel of radar data and impacted the warning decision making of National Weather Service (NWS) warning forecasters. Since the Build 10 upgrades to the WSR-88Ds in 2008, spatial resolution of radar data was enhanced from legacy resolution to super-resolution. The improvement should result in both more detailed storm features and storm feature identification at distances 50% greater in range. These details ought to have allowed for increased lead time, decreased false alarm ratio (FAR), and better warning decision making. However, no formal study was previously completed to determine if these expectations had been realized. For this study, a survey was sent to forecasters from all Weather Forecasting Offices (WFOs) in all regions of the NWS who were expected to have experience using radar data in a warning decision environment. While understanding of the technological aspects of super-resolution data appears to be lacking, 50% to 70% have seen a perceived improvement in storm feature appearance and 30% to 50% have seen a perceived improvement in identification at farther ranges. A majority also agrees there is potential for increased lead time and decreased FAR, but it is too early to tell numerically how super-resolution has impacted them. The most surprising change was that 60% have noticed positive changes to wintry precipitation echoes due to super-resolution data. Overall, there is strong NWS support for super-resolution data and mainly positive impacts in the warning decision environment. However, for some aspects, such as lead time and FAR, it is too early to clearly quantify results.

1. INTRODUCTION

The current network of Weather Surveillance Radar 1988-Doppler (WSR-88D) radars of the National Weather Service (NWS) were deployed operationally in 1990. Since then, continuous upgrades have been made to the WSR-88Ds to improve performance and to help achieve the NWS mission: to provide "weather, hydrologic, and climate forecasts and warnings for the United States, its territories, adjacent waters and ocean areas, for the protection of life and property and the enhancement of the national economy" (National Weather Service Internet Services Team 2005). This study will focus on the operational impacts of the Build 10 upgrades, which occurred in the Spring and Summer of 2008.

The Build 10 upgrades led to a major enhancement in spatial resolution of all the base moments of WSR-88D data, referred to as super-resolution. The resolution for all the base moments for super-resolution is 0.25 km by 0.5 degree which is twice the legacy resolution for Doppler velocity and spectrum width (0.25 km by 1.0 degree) and eight times the legacy resolution for reflectivity (1.0 by 1.0 degree; Fig. 1). Additional key differences can be found in Table 1.

To achieve the resolution of 0.25 km by 0.5 degree for the base moments, the effective beamwidth of the WSR-88D network had to be

Corresponding author address: Jonathan M. Vogel, 348 Spohn Road, Sinking Spring, PA 19608.
E-mail: jmvogel512@gmail.com

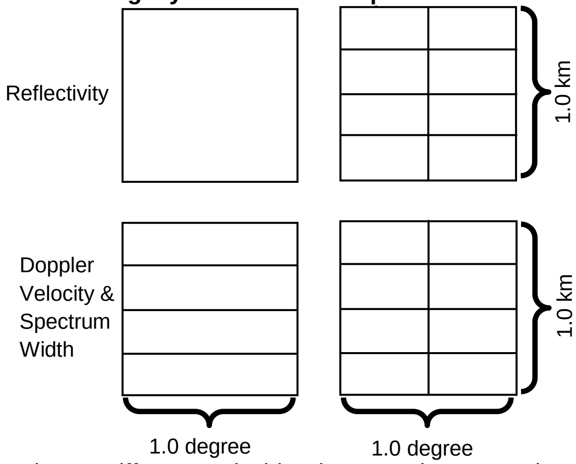

Fig. 1. Differences in bins between legacy and super-resolution reflectivity, Doppler velocity, and spectrum width products; modified from Wood et al. (2009, Fig. 2).

Table 1. Comparison of key points between super-resolution and legacy resolution. Data obtained from Saffle et al. (2009) and Torres and Curtis (2007).

	Super-Resolution	**Legacy Resolution**
Reflectivity Resolution	0.25 km by 0.5 degree	1.0 km by 1.0 degree
Doppler Velocity Resolution	0.25 km by 0.5 degree	0.25 km by 1.0 degree
Spectrum Width Resolution	0.25 km by 0.5 degree	0.25 km by 1.0 degree
Range	Reflectivity: 460 km Doppler Velocity: 300 km Spectrum Width: 300 km	Reflectivity: 460 km Doppler Velocity: 230 km Spectrum Width: 230 km
Ingested by Algorithms	No	Yes
Effective Beamwidth	1.03 degrees	1.39 degrees

narrowed from 1.39 degrees to 1.03 degrees (Wood et al. 2001, Table 1; Torres and Curtis 2006; Torres and Curtis 2007). The beamwidth of a radar beam is the angular width where the transmitted power falls off by one-half the peak power at the center of the beam. During the time it takes to collect enough pulses for a given azimuth, the radar antenna is rotating resulting in a broadening of the beam. The combination of the actual beamwidth with the broadening due to antenna rotation results in what is called the effective beamwidth (Brown et al. 2002).

For the required effective beamwidth at the 0.5 degree azimuthal sampling interval of super-resolution to be realized, two methods were previously proposed: halve the number of transmitted pulses while keeping the same rotation rate for 1.0 degree azimuthal sampling or decrease the rotation rate while keeping the same number of samples as the 1.0 degree azimuthal sampling (Wood et al. 2001; Brown et al. 2002). However, neither of these methods is currently implemented to achieve super-resolution data. Decreasing the rotation rate would have resulted in longer Volume Coverage Patterns (VCPs) which is neither practical nor desirable for forecasters. While halving the number of pulses per radial would achieve the proper effective beamwidth for super-resolution, there would not be enough pulses per radial to accurately use clutter filtering and other data quality algorithms.

To reduce the effective beamwidth, Torres and Curtis (2007) proposed oversampling and data windowing as the only solution if the operational goals prior to super-resolution are to be preserved. In legacy resolution, all pulses within the 1.0 degree sampling radial receive equal weight (Fig. 2a). In super-resolution, however, for every 0.5 degree azimuthal sampling interval, the system collects overlapping 1.0 degree radials. The pulses close to the center of the overlapping radial are more heavily weighted than the pulses farther from the center (Fig. 2b). The oversampling and data windowing used to achieve the effective beamwidth leads to noisier data and higher statistical error (increasing standard deviation by a factor of 1.4 (Curtis et al. 2003)). However, this error is tolerable based on previous studies on simulated and experimental data, which are presented below.

Super-resolution data, however, cannot be ingested by the algorithms currently used with the WSR-88D network. The initial proposed solution to this problem was to send both legacy and super-resolution data across the data feed. But, this solution required too much bandwidth and was not practical for operations. Therefore, Torres and Curtis (2007) proposed a formula that would combine super-resolution data back into legacy resolution to be ingested by the algorithms.

Previous studies on both simulated and experimental super-resolution data have shown great improvements over legacy resolution products. Improvements include but are not limited to: small scale storm features, gust fronts and boundaries, hook echoes, bounded weak echo regions (BWER), mesocyclone rotation signatures, and tornadic vortex signatures (TVS) all of which were either not as readily depicted at legacy resolution or are now being seen in clearer detail. Small scale features have also been shown to be more easily identifiable and at distances 50% greater than before (Brown et al. 2005, Curtis et al. 2003). Brown et al. (2002) and Wood et al.

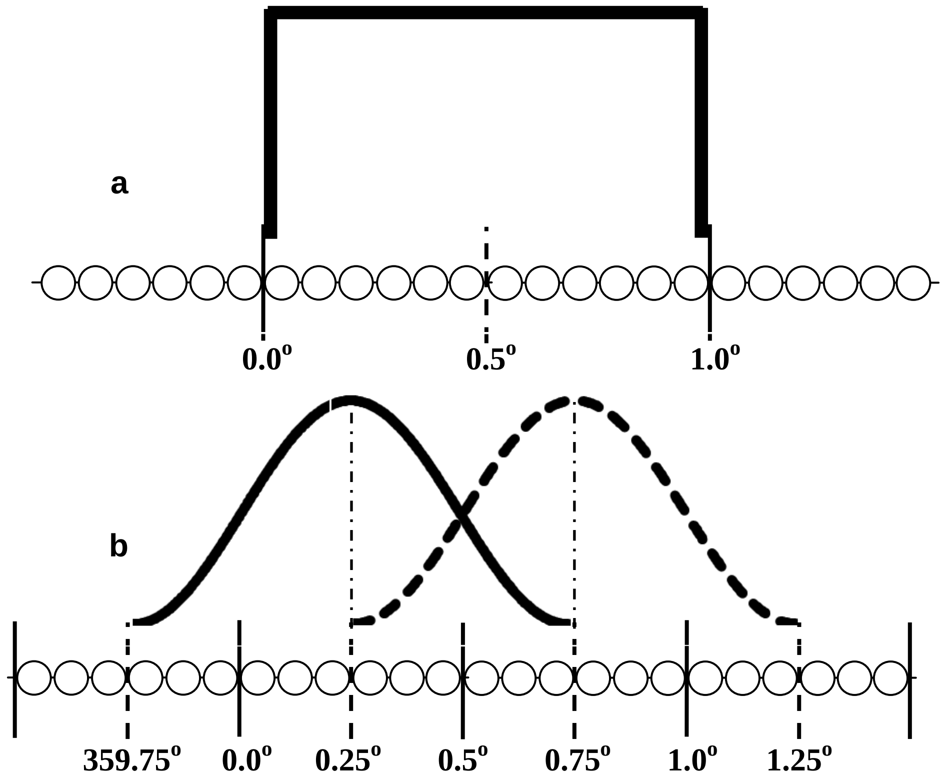

Fig. 2. Examples of the windowing techniques used. For (a) legacy resolution, for a single 1.0 degree radial example, the rectangular window is used. For (b) super-resolution, for two 0.5 degree radials examples, either the von Hann or the Blackman windows are used.

(2001) both demonstrate that super-resolution data allow for stronger mesocylone signatures and TVSs. The narrower effective beamwidth allows for detection of smaller tornadoes and TVSs that previously would have been too small to detect at legacy resolution. The improvement in all aspects of severe storm feature identification brought by super-resolution can lead to increased lead time on potentially dangerous storms.

The results of these simulated studies lead us to believe that this should be reflected in operations through better warning decisions and increased lead times. However, this belief has not been previously studied. In this study, we surveyed NWS meteorologists from all regions of the NWS to assess their understanding of super-resolution data and how it has impacted warning decision making.

2. METHODOLOGY

Data used in this study were obtained via anonymous, voluntary participation in an online survey. Approximately three potential participants were randomly chosen from each of the 122 Weather Forecast Offices (WFOs) within all six regions of the NWS for a total of about 400 potential participants. Those selected were lead forecasters, senior meteorologists, or journeyman forecasters identified through a NOAA directory. This provided a weighted random selection, which means each region of the NWS did not receive equal representation in the selection due to the unequal number of WFOs and meteorologists in each region. The Alaska and Pacific regions received the lowest selection with about 20 each, while the Central regions received the highest selection at about 115. The other three regions had between 70 and 90 meteorologists selected. Once the 400 potential participants were chosen, an email was sent out to all selections informing them about the nature of the survey and providing a link to the online survey.

The survey included true and false, open comment, and Likert scale based questions. The topics of those questions were background and training on super-resolution, signature recognition, and warning-related issues. All questions were optional, so each participant could choose to answer any of the questions. The survey was open for approximately a two week time period, and the results were gleaned from the responses of all the participants. A copy of the survey is provided in the appendix.

3. RESULTS

The goal of the survey was to reach an equal amount of meteorologists from all 122 WFOs in all 6 regions. Overall we had a 12% response rate. Table 2 shows that in terms of weighted response percentage, all the regions (except Pacific) were fairly equally represented, despite the Central region having the highest total responses. Fig. 3 shows that of those who responded to the survey, 80% have been in the NWS for more than three years and 60% more than 10 years suggesting considerable experience among surveyed warning forecasters.

The Warning Decision Training Branch (WDTB) produced training for the Build 10 upgrades to the WSR-88D designed to help familiarize meteorologists with the changes, new features, and the aspects of the super-resolution data. While the training was not required, the Meteorologist in Charge (MIC) or Science Operations Officer (SOO) could require the meteorologists to complete this training. Of those surveyed, over 80% were either required to complete the training or were provided a seminar by the MIC or the SOO. Of the 20% that were not required to complete the training, 60% did take it on their own. That leads to an overall completion of some form of training at greater than 90%. However, when looking at the responses to questions on super-resolution data, there appears to still be some confusion.

Super-resolution data has higher statistical error than legacy resolution data, however, over 60% of those surveyed believe otherwise. While a majority of participants rightfully understand that super-resolution data is not ingested by the algorithms, nearly 30% believe the opposite. Super-resolution data is only produced at split-cut levels of the VCP, however, again, over 30% believe otherwise. Super-resolution data can show higher reflectivity and higher velocity signatures than legacy resolution data, and about 80% of participants understand that for each.

90% of the participants have used super-resolution data in their work environment, with 85% of participants having used both legacy resolution and super-resolution at some point in their career. Nearly 85% of all participants prefer super-resolution reflectivity and velocity products to legacy resolution products citing the benefits greatly outweigh the costs. About 5% still prefer the use of legacy resolution over super-resolution, however no reasons were given for this preference. With spectrum width products, only 28% stated a preference suggesting that spectrum width continues to be underused in the NWS. However, a few comments indicated that some forecasters have begun using spectrum width for the first time.

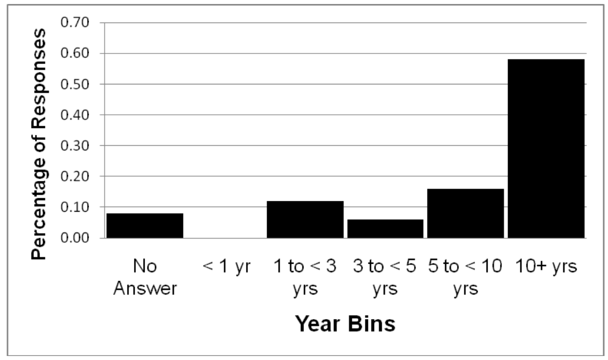

Figure 3. Responses to the years of experience using WSR-88D in warning decision making in the NWS.

With regards to how super-resolution has affected lead time, almost half of those surveyed (yes, no, not applicable, and no answer were acceptable answers to this question) did not think lead time has increased. However, a few meteorologists stated that while there has been no noticeable increase in lead time, super-resolution has only been available for a year and there is certainly potential for it to increase. Others who feel there is an increase stated they can see descending mesovortices and wind cores more easily. Others have stated these more easily identified vortices may be leading to a tendency to overwarn until meteorologists have had time to become calibrated to the new data. One meteorologist made an interesting point stating that some more experienced meteorologists show hesitance as to whether one pixel really is a developing storm feature.

False alarm ratio (FAR) is another concern

Table 2. Responses to WFO location, the percentage of all responses, and then weighted percentage based on the number of recruitments sent to each region

	Pacific	Alaska	Western	Central	Southern	Eastern	No Answer	Total
Responses	0	2	5	22	8	9	4	50
Percentage	0.0	4.0	10.0	44.0	16.0	18.0	8.0	100
Weighted %	0.0	10.0	7.1	19.3	8.7	10.8		12.7

with the super-resolution data. Like lead time, about half of those surveyed have not seen a change in FAR. While they have not seen an increase in FAR, it does not negate the possibility of change. It was stated that finer scale features could prompt more tornado false alarms, but no proof has been observed yet. Weak tornado signatures have been seen by many, but the results have been mixed. Some said this has led to a tendency to overwarn. One meteorologist said they work with experienced forecasters that err on the conservative side with regards issuing tornado warnings so super-resolution has not affected their FAR. Finally, another meteorologist stated they have seen a decrease in FAR with super-resolution data because they are now waiting for stronger circulations to develop.

Super-resolution data was intended to allow for storm features to be both more clearly detectable and be seen at farther ranges from the radar. On average, about 55 to 75% of those surveyed either agreed or strongly agreed that storm features are more easily identifiable (Table 3a). On average, about 30 to 45% of the participants either agreed or strongly agreed that storm features can be seen at farther ranges (Table 3b). Finally, as far as general appearance of super-resolution data (Table 4), there was about an equal amount of indecisiveness amongst the participants, however there was some slight agreement that super-resolution is noisier and less smooth than legacy resolution. Interestingly, there were two participants who actually agreed that super-resolution is both noisier and smoother, which seems to be a conflicting report. Several participants mentioned the following features: rear and forward flank downdrafts, vortices, and hook echoes sticking out ahead of a gust front were all either previously undetectable without super-resolution or not observed at such detail. Another participant stated quasi-linear convective systems (QLCS), especially reflectivity notches associated with mesovortices, are more easily identifiable and have led to increased lead time on damaging winds and brief tornadoes. One other participant also noted that super-resolution has made ground clutter, especially wind farms, more prominent than before.

Aside from the severe weather, meteorologists were also questioned on if and how super-resolution data has impacted the appearance wintry precipitation. Out of those that answered the question, only about 10% are not affected by wintry precipitation, and over 60%

Table 3. Display of the distribution of responses to the Likert scale based questions dealing with the effects of super-resolution data on (a) storm feature appearance and (b) storm feature identification at distances farther away from the radar.

a.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	N/a	No Answer
Hook Echoes	0%	2%	4%	32%	38%	6%	18%
BWER	0%	4%	14%	32%	26%	6%	18%
Gust Fronts / Boundaries	0%	2%	4%	26%	50%	0%	18%
Mesocyclones / TVS	0%	2%	6%	42%	28%	4%	18%

b.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	N/a	No Answer
Hook Echoes	0%	8%	12%	40%	8%	6%	26%
BWER	0%	10%	16%	30%	8%	10%	26%
Gust Fronts / Boundaries	0%	6%	26%	32%	4%	6%	26%
Mesocyclones / TVS	0%	10%	20%	32%	6%	6%	26%

Table 4. Display of the distribution of responses to the Likert scale based question relating super-resolution data to legacy resolution data.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	N/a	No Answer
Noisier	4%	12%	10%	42%	8%	0%	24%
Smoother	4%	28%	20%	10%	12%	0%	26%
More AP	2%	10%	44%	16%	0%	2%	26%
More Ground Clutter	2%	12%	34%	20%	2%	4%	26%

have seen a noticeable impact by super-resolution data. Several participants mentioned how super-resolution has allowed for easier identification of the melting layer, the rain/snow line, and bright band. Others mentioned it has allowed for better detection of smaller particles such as drizzle, flurries, light snow, and frozen precipitation. And a few participants mentioned how super-resolution gives a good representation of where the heaviest snowfall is occurring along with clearer local variances and texture gradients in precipitation intensity.

In the closing comments section, many of those surveyed showed support for the improvement to super-resolution data. Several said even though it's noisier, they would never consider going back. Some stated they have begun using spectrum width for the first time with super-resolution. One said that with super-resolution the forecaster has to be careful not to become focused on minute details and lose sight of the big picture. Others said that during the early months, storms appeared more intense than before leading to the likelihood of overwarning, however, as forecasters got used to the look and feel of super-resolution it led to better warning decision making.

4. DISCUSSION AND CONCLUSION

Super-resolution radar data has only been available for about a year since the Build 10 upgrades to the WSR-88D network. Previous studies have suggested that super-resolution should allow for enhanced storm feature identification and improved recognition of storm features at farther ranges resulting in better warning decision making and increased lead time. Based on the results of our survey to all WFOs in all NWS regions, super-resolution has been a welcome and helpful upgrade. While super-resolution displays higher values of reflectivity and velocity, has higher statistical error, and cannot yet be ingested by algorithms, most warning forecasters in this study would not go back to legacy resolution.

The survey gave a decent sampling of most regions of the country, especially those with significant amounts of severe weather. In looking at the general responses of those who participated, the large amount of experience was the most striking. This could be the result of the growing amount of meteorological jobs outside of the NWS. In today's job world, more and more private sector jobs are becoming available resulting in a lower number of younger, less experienced journeyman forecasters and a larger number of meteorologists who have been in the NWS for a long time. This skewness towards greater experience should suggest better warning decision making to begin with, however, introducing new technology can stymie improving warning decisions to a certain degree.

Despite the preference to the new super-resolution data, there is a lack of understanding of the technical aspect. This could be due to forecasters paying more attention to the forecasting aspects of training modules and less attention to the technical aspects. Though, it could simply be a time factor of not enough hours in the day. NWS meteorologists deal with busy and hectic work schedules, from ever rotating shifts to the constantly changing weather situation. On an average day, NWS meteorologists have varying roles including short-term forecasts, long-term forecasts, and public communication. In addition, days when severe weather is present, meteorologists often put tasks on hold to observe, forecast, and warn on strong storms. During a severe weather outbreak, meteorologists are responsible for issuing warnings, updating warnings, communicating with other WFOs when storms cross County Warning Area (CWA) lines, and communicating with and receiving storm reports from emergency managers, trained spotters, and the general public. At the same time, technology is ever changing. Updates are being made to the look and feel of the WSR-88D data. Training branches of NOAA like the WDTB are producing training courses and modules with the hope and expectations that forecasters will utilize them.

Based on the questions on the technical aspects, uncertainties have arisen about the effectiveness of the training programs. While it should not be detrimental to warning decision making, it is beneficial to know the technical aspects of new products. For example, if warning forecasters more clearly understood that super-resolution displays higher reflectivity and velocity values while having a higher statistical error it may have allowed the meteorologists to become "calibrated" more quickly to the differences between super-resolution and legacy. Understanding that super-resolution is produced only at split-cut levels is also important so meteorologists know what to expect when looking at the data.

For use in the warning decision environment, there is strong agreement that super-resolution has allowed for better storm feature identification. The most significant improvement has been the ability to detect small scale storm features better and to more easily resolve developments within storms sooner. Although, one participant did comment that some older forecasters are more hesitant to buy into the fact that one pixel of development is enough to imply something. The most noted has been the ability to detect descending cores, downdrafts, and quasi-linear convective systems features. However, as far as easier detection at farther ranges, there is slightly less agreement. Being able to identify features farther away allows for more accurately forecasting storms at the outer regions of the radar domain, especially in regions of the country where radar coverage is limited. Also, having better storm detection at farther ranges should lead to an increase in lead time. However, one question arises from these results. 36% agreed or strongly agreed that boundaries and gust fronts are more easily recognized at farther distances with super-resolution. However, at farther ranges, the radar beam is farther off the ground due to the elevation angle of the beam and the curvature of the earth. So, these shallow features should typically not be easier to indentify at farther ranges. This brings to question whether the curvature of the Earth factor has been forgotten.

While lead time was expected to increase and FAR decrease with super-resolution data, it seems to be too early to tell. Many of the participants agree that there is the potential for improvements in both lead time and FAR, however they say that it will take getting used to the new look and feel of the super-resolution data before these expectations are realized. Others have already noticed immediate improvement due to better detection of certain storm features. However, at this time it appears it is too early to accurately measure and participants have given mixed feelings on the subject.

An unexpected result from super-resolution has been the impact on wintry precipitation echoes. In all previous work, expectations were for improvements in severe storm signatures leaving winter weather somewhat neglected. However, results have shown a perception of improvement in wintry precipitation signatures. Meteorologists were pleased by the ability to detect the rain/snow line and banded precipitation more often. In addition, the ability to distinguish smaller particles such as drizzle and flurries is surprising. Based on these observations by meteorologists, super-resolution has promising aspects outside the realm of severe storm interrogation.

In general, meteorologists show strong support for the new super-resolution data. While it is not perfect and takes some getting used to, the trade offs are much more beneficial than sticking with legacy resolution. While super-resolution can lead to some new looks to storms and signatures, overall, it has allowed for improvements in warning decision making and some forecasters using spectrum width for the first time. However, until forecasters get used to the new texture of super-resolution data there may be the tendency to overwarn leading to questions regarding super-resolution and FAR. Also, they must learn to balance the enhanced storm feature details without losing sight of the overall picture.

Additionally, while there was about a 12% response rate from those selected as possible participants, it would be ideal to obtain more information on how super-resolution has affected warning decision making. Another year may allow for continued study on this topic, including: better options on how both lead time and FAR have been impacted, how super-resolution has impacted winter weather echoes, and any new thoughts on the impacts of super-resolution on warning decision making.

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7. APPENDIX

7.1 *Super-Resolution Survey*

1. Once you have read the above information and asked any questions, please choose whether or not you would like to participate in this survey.

I have read the above information. I have asked questions and have received satisfactory answers. I consent to participate in this study.	
I do not wish to participate in this study.	

(Consenting to participate will take the participant to the next question. Choosing not to participate will take them to the end of the survey.)

2. Please mark in which region your local forecast office is located.

Eastern Region	
Central Region	
Southern Region	
Pacific Region	
Alaska Region	
Western Region	

3. How long have you used WSR-88D data in warning operations for the NWS?

Less than 1 year	
1 to less than 3 years	
3 to less than 5 years	
5 to less than 10 years	
10 years or longer	

4. Did your office require you to complete or provide a seminar on Build 10 / Super-Resolution training?

Yes	
No	

   a. If no, did you complete it on your own?

Yes	
No	

5. Have you used super-resolution data (0.5 degree x 0.25 km) to interrogate weather related radar features?

Yes	
No	

6. Have you used legacy/recombined resolution data (1 degree x 1 km) to interrogate weather related radar features?

Yes	
No	

7. If the option is available, when storms approach the edge of the radar domain, do you consult neighboring radars?

Yes	
No	
N/a	

8. a. Which reflectivity product do you prefer when making a warning decision?

4-bit	
8-bit Legacy Resolution (Recombined data)	
8-bit Super-Resolution	
No Preference	

b. Which velocity product do you prefer when making a warning decision?

4-bit	
8-bit Legacy Resolution (Recombined data)	
8-bit Super-Resolution	
No Preference	

c. Which spectrum-width product do you prefer when making a warning decision?

3-bit	
8-bit Super-Resolution	
No Preference	

9. Please identify the following statements about super-resolution as true or false.

Statement	**True**	**False**
Super-resolution radar data have higher statistical error in its computation		
Algorithms are computed using super-resolution data		
Super-resolution data only appear on the split-cut elevations		
Super-resolution reflectivities tend to be higher than legacy/recombined reflectivities		
Super-resolution velocities tend to be higher than legacy/recombined velocities		

10. Since super-resolution data have become available, have you seen a change in lead time on storm warnings (i.e. tornado, severe thunderstorm, flash flood)?

Yes	
No	
N/a	

a. Please provide any specific examples and/or comments you might have. If you wish, you can share a specific date and radar where this occurred.

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11. Since super-resolution data have become available, have you noticed an increase in the amount of tornado false alarms?

Yes	
No	
N/a	

a. Please provide any specific examples and/or comments you might have. If you wish, you can share a specific date and radar where this occurred.

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12. Please indicate your level of agreement with the following statement for the mentioned radar features: "The following features are ***more easily identifiable*** with super-resolution data compared to legacy/recombined resolution data".

Statement	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**	**N/a**
Hook echoes						
Bounded Weak Echo Regions (BWER)						
Gust Fronts / Boundaries						
Visually identified mesocyclones and/or tornadic vortex signatures (TVS)						
Hail / Three Body Scatter Spikes (TBSS)						

13. Are there any other radar-identified signatures that appear significantly different with super-resolution data compared to legacy/recombined resolution data? If so, please indicate those features along with comments in the space provided below.

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14. Please indicate your level of agreement with the following statement for the mentioned radar features: “The following features can be seen ***at farther ranges*** with super-resolution data compared to legacy/recombined resolution data”.

Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	N/a
Hook echoes						
Bounded Weak Echo Regions (BWER)						
Gust Fronts / Boundaries						
Visually identified mesocyclones and/or tornadic vortex signatures (TVS)						
Hail / Three Body Scatter Spikes (TBSS)						

15. Are there any other radar-identified signatures that appear to be visible at differing ranges with super-resolution data compared to legacy/recombined resolution data? If so, please indicate those features along with comments in the space provided below.

16. Please indicate your level of agreement with the following statement for the mentioned radar data: “Super-resolution data _____________ than legacy/recombined resolution data”.

Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	N/a
are often noisier						
are often smoother						
have more Anomalous Propagation (AP)						
have more ground clutter						

17. If your forecasting office experiences wintry precipitation (snow, sleet, freezing rain, etc.), have super-resolution data impacted the appearance of it?

Yes	
No	
N/a	

a. If yes, how have super-resolution data impacted the appearance of wintry precipitation?

____

18. If there are any other specific examples you would like to share concerning the differences between super-resolution and legacy/recombined resolution data that may lead to a differing interpretation of the two products, please comment below. If you wish, you can share a specific date and radar where this occurred.

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19. We greatly appreciate your time. Thank you.