CASA's Impact on Radar-Based Wind Assessments

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METHODOLOGY

Introduction

The Center for Collaborative Adaptive Sensing of the Atmosphere (CASA) is creating a new paradigm for radar systems based on low-cost networks of X-Band radars that collect high spatial and temporal resolution data from the lower troposphere. CASA operates a 4 node radar test bed in south-west Oklahoma to research the capabilities of this new technology and to understand how CASA data will impact decision making by users such as National Weather Service forecasters. We hypothesize that CASA technology will better inform forecasters, improve their performance, and ultimately improve severe weather warnings. This study was designed to measure the impact of CASA data on wind speed assessments, a critical component of the severe thunderstorm warning process.

Experimental Task

Forecasters predicted winds speed at the ground, 2 to 5 minutes into the future at specific locations using only NEXRAD data or CASA and NEXRAD data combined. Case studies were created from data collected in the Oklahoma test bed. Ground sensor readings from the Oklahoma Mesonet (McPherson et al., 2007) provided ground truth. This ground truth was used to calculate absolute wind speed assessment error.

Six scenarios, each approximately 12 minute long, were chosen from May 7, 2008, where a cold-core system produced small bowing cells and supercells. Participants made predictions based on these data. The scenarios had similar but discrete storm cells producing straight line winds in the 20-50 kt range at locations with adequate CASA and NEXRAD coverage.

Participants

Sixteen National Weather Service forecasters (12 male, 4 female) with operational experience ranging from 5 to 25 years (M = 14.4 years, SD = 5.9) participated in the experiment at the 33rd Annual meeting of the National Weather Association in Louisville, KY, October 11-16, 2008.

Independent Variables

• *Weather Scenario*. Weather scenario refers to the 6 selected atmospheric situations in time order, 1st to 6th.

• *Data Source*. Participants evaluated weather scenarios with only NEXRAD data or both CASA and NEXRAD data. Data source indicates if radar data were supplied from "NEXRAD Only" or "CASA & NEXRAD".

Dependent Variables

• *Wind Speed Assessment*. Wind speed assessment is the ground level wind speed forecasted for the target location by the participant to the nearest 1 knot.

• *Absolute Wind Speed Assessment Error*. The absolute value of the difference between the wind speed assessment and the automated ground sensor reading.

• *Assessment Confidence*. After providing their wind speed assessment participants were asked "how confident are you in this estimate" on a scale from 1-"Not Confident" to 7-"Very Confident".

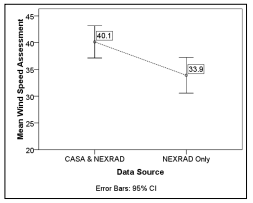
• *Warning Decision*. After providing their confidence rating participants were asked "do these radar based winds indicate a warning is needed" and a "Yes" or "No" response was recorded.

RESULTS

Wind Speed Assessment

The mean wind speed assessments were statistically higher when both CASA and NEXRAD data were available as opposed to when only NEXRAD data were available ($F_{(1,28)}$ = 15.264, p = 0.001).

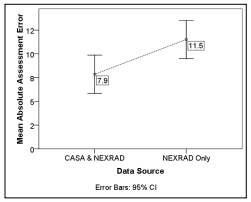
• Mean with CASA & NEXRAD: 40.1 kt
• Mean with NEXRAD Only: 33.9 kt



Absolute Wind Speed Assessment Error

The mean of the absolute values of the wind speed assessment errors were statistically smaller when both CASA and NEXRAD data were available as opposed to when only NEXRAD data were available ($F_{(1,28)}$ = 7.309, p = 0.012).

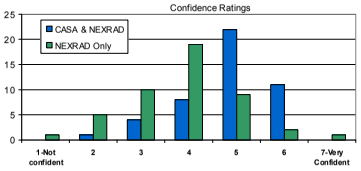
• Mean with CASA & NEXRAD: 7.9 kt
• Mean with NEXRAD Only: 11.5 kt



Assessment Confidence

Forecaster confidence assessments were ranked statistically higher when both CASA and NEXRAD data were available as opposed to when only NEXRAD data were available (χ^2 = 16.030, df=1, p < 0.0005).

• Mode with CASA & NEXRAD: 5
• Mode with NEXRAD Only: 4

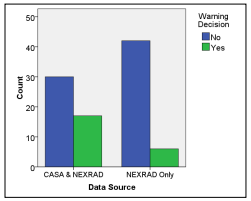


Warning Decision

The proportion of decisions "Yes" to warn was statistically higher when both CASA and NEXRAD data were available as opposed to when only NEXRAD data were available (χ^2 = 7.251, df=1, p = 0.007).

• With CASA & NEXRAD: 30 of 47
• With NEXRAD Only: 6 of 48

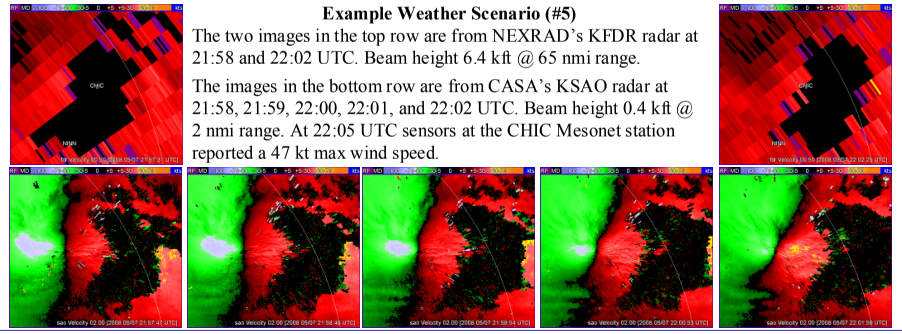
Scenario 5 with NEXRAD Only had all "No" responses (8) whereas CASA & NEXRAD had all "Yes" responses (7) and one missing response.



Example Weather Scenario (#5)

The two images in the top row are from NEXRAD's KFDR radar at 21:58 and 22:02 UTC. Beam height 6.4 kft @ 65 nmi range.

The images in the bottom row are from CASA's KSAO radar at 21:58, 21:59, 22:00, 22:01, and 22:02 UTC. Beam height 0.4 kft @ 2 nmi range. At 22:05 UTC sensors at the CHIC Mesonet station reported a 47 kt max wind speed.



DISCUSSION

Since wind speed plays a critical role in the definition of severe thunderstorms, the purpose of this study was to measure the impact of CASA radar data on wind assessment performance.

The results reported herein clearly indicate that for wind speed assessments CASA radar data can simultaneously
• increase wind speed estimates
• reduce assessment error
• increase confidence

This outcome is particularly promising given that
• data are from experimental radars
• participants were given minimal training
• the radar display and computer-interface were unfamiliar
• many participants said CASA data confirms their mental model

The increase in wind speed assessments supports research by Brown and Wood (Brown et al., 2005) which predicts that increased spatial sampling results in higher radial velocity readings. The shift in warning decisions when given CASA data is especially notable because only one experimental task was covered by an actual warning according to NWS archives.

As systems such as CASA, NEXRAD SuperRes, and MPAR (Heinselman, Priegnitz, Manross, Smith, & Adams, 2008) come on-line, the forecasting community may need to revisit policies and thresholds for issuing warnings.

Future Work

The current study could be enhanced by the systematic control of radar beam attributes. Update rate, beam height, wind-to-beam intersection angle, and sampling fidelity each influence performance. Future work could quantify the impact of these attributes individually. Additional measures of performance could be used including the size of warnings, their duration, and lead time. Finally, a standardized and rigorous training tool for CASA data would help remove any novelty effects from future studies.

ACKNOWLEDGMENTS

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