Performance Analysis (Informational Brief)

**Clutter Environment Analysis Using Adaptive Processing (CLEAN-AP)**

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And NSSL/NOAA
OUTLINE

- Simulation results
  - Clutter Detection
  - Clutter Filtering
- Real data analyses and comparisons
  - KEMX (Can you see the mountains?)
  - KABX (Are the mountains still there?)
  - KCRI (What happened to the zero-isodop?)
  - KTLX (Where is the zero?)
- Summary and recommendation
Clutter Detection Performance
(SNR 20 dB, SW 4 m/s, Nyquist 26.6 m/s)
Clutter Detection Performance
(SNR 20 dB, SW 4 m/s, Nyquist 11.7 m/s)
Clutter Filtering

Clear Air Reflectivity Bias

WSR-88D data from Ice et al. 2004
Clutter Filtering
Surveillance Reflectivity Bias

WSR-88D data from Ice et al. 2004
Clutter Filtering
Doppler Reflectivity Bias

WSR-88D data from Ice et al. 2004
Clutter Filtering Suppression Comparison

GMAP

CLEAN-AP
Clutter Filtering Velocity Bias Comparison

GMAP

CLEAN-AP
Clutter Filtering Spectrum Width Bias Comparison

GMAP

CLEAN-AP
RDA Build 11.0 Beta Test (CMD implemented)

- Missed CMD detections in RDA Build 11.0
  - Level-I data indicated that, at times, two distinct targets were captured by the moving antenna
  - Phase and power changes between clutter targets caused low CPA values
- Mitigated CMD missed detections in RDA Build 11.1
Mountainous Terrain
And
Low Level Clutter

KEMX

Mountainous terrain above Catalina Foothills

WSR-88D Located Southeast of Vail, AZ
Mountainous terrain above Catalina Foothills
KEMX
Build 11.0
Hot Spots in Mountainous Terrain
And
Low Level Clutter

Data provided by ROC : Jane Krause
KEMX
Build 11.1
Hot Spots in Mountainous Terrain
And
Low Level Clutter

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KEMX
CLEAN-AP
Hot Spots in Mountainous Terrain
And
Low Level Clutter
KEMX
Clutter Suppression

CMD & GMAP Build 11.1

Missed Detections
Censored to ~53 dB

CLEAN-AP

Detected
60 dB

Data provided by ROC : Jane Krause
KABX
Albuquerque, NM
Are the mountains still there?

Terrain

Unfiltered
KABX
Albuquerque, NM

CMD & GMAP Build 11.1

CLEAN-AP

November 16, 2009
KCRI (ROC Testbed) Norman, OK

What happened to the zero-isodop?

- Zero-isodop loss
  - Weather with narrow spectrum width and near zero velocity has nearly the same spectrum as clutter
KCRI (ROC Testbed) Reflectivity

Unfiltered

CLEAN-AP
KCRI (ROC Testbed) Velocity

Unfiltered

CLEAN-AP
KTLX
Oklahoma City, OK
Where is the zero?

- Snow event with imbedded storms
KTLX Reflectivity

Unfiltered

CLEAN-AP

KTLX (OKC, OK) 0434Z 27OCT2006
Reflectivity - Unfiltered

KTLX (OKC, OK) 0434Z 27OCT2006
Reflectivity - CLEAN-AP

No detectable zero-isodop loss!
KTLX
Spectrum Width

Unfiltered  CLEAN-AP

PPP Processing  Cross-Spectral Processing
Summary

- CLEAN-AP
  - Performance exceeds NEXRAD standards
  - Clutter Detection is comparable to CMD
    - Better performance in mountainous environments
    - Better performance in low clutter environments
  - Clutter Suppression exceeds GMAP
  - Better Data Quality
**Recommendation**

- CLEAN-AP is a **real-time, automatic, integrated** approach for ground clutter **detection and filtering** that produces data with the **best possible quality** while meeting NEXRAD technical **requirements**
  - Improved performance compared to current approach
- We recommend considering the CLEAN-AP filter as a ground clutter mitigation solution for the NEXRAD network
  - TAC endorsement is needed
BACK UP SLIDES
Detection and Filtering Requirements

- NEXRAD Technical Specifications
  - Detection
    - ROC tentative (DQ Subcommittee: System Specifications; Chair: Rich Ice)
      - SP: $\geq 50\%$ @ -10 dB, $\geq 90\%$ @ -5 dB, and 100% @ 5 dB
      - DP: $\geq 50\%$ @ -15 dB, $\geq 90\%$ @ -5 dB, and 100% @ 5 dB
      - May need lower bound - $\leq 5\%$ @ -30 dB
    - Clutter Mitigation Decision (CMD) System - NCAR
  - Filtering
    - WSR-88D System Specification
      - Clutter Suppression
        - Reflectivity – at least 30 dB
        - Doppler – Range of usable velocities for 20 dB ($\pm 2$ m/s), 29 dB ($\pm 3$ m/s), and ($\pm 4$ m/s) 50 dB
    - Gaussian Model Adaptive Processing (GMAP™) filter – Vaisala
KCRI (ROC Testbed) Spectrum Width

Unfiltered

CLEAN-AP
Adaptive Windowing

![Graph showing CLEAN-AP Window Selection with different window types: Blackman-Nuttall, Blackman, Von Hann, Hamming, Rectangular. The x-axis represents CSR (dB) and the y-axis represents window selection.](image)
Phase Bias

Magnitude (SNR = 20 dB, \( v = 0 \) m/s)

Phase

\( \sigma_v = 4 \)
\( \sigma_v = 0.3 \)

Phase Bias
Reflectivity
PAR

Unfiltered

CLEAN-AP
Velocity PAR

Unfiltered

CLEAN-AP
Spectrum Width
PAR

Unfiltered

CLEAN-AP
GMAP vs CLEAN-AP
Notch Width

Notch Width Selection

Normalized Notch Width (Coeff/Max(Coeff))

CSR (dB)
Clutter Filtering Velocity Bias Comparison

GMAP

CLEAN-AP
Clutter Filtering Velocity Bias Comparison

GMAP

CLEAN-AP
Clutter Suppression Sample Size Analysis

CLEAN-AP Clutter Suppression Capability

![Graph showing CLEAN-AP Clutter Suppression Capability with CSR (dB) on the x-axis and different curves representing various sample sizes.]