Clutter Environment Analysis using Adaptive Processing: The CLEAN-AP Filter

(Informational Briefing)

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What is the CLEAN-AP filter?

CLEAN-AP is a novel real-time, automatic, integrated approach for ground clutter detection and filtering that produces data with the best possible quality while meeting NEXRAD technical requirements.
Outline

• Motivation
• Current approach
  – Maps/CMD + GMAP
• Proposed alternative
  – The CLEAN-AP filter
• Summary and recommendations
• Stay tuned: Performance analyses and comparisons with current approach
WSR-88D Strategic Directions
Snow et al. (2003)

- “Produce the best quality data possible from the WSR-88D throughout the remainder of its service life.”
  - “…these applications require that quality control/assurance be applied automatically.”
  - “Signal processing could be improved to almost completely mitigate ground clutter…”
WSR-88D Clutter Mitigation
at the signal processing level (ORDA)

Ground Clutter Detection

Control

Ground Clutter Filtering

Unfiltered data

Filtered data

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Ground Clutter Detection

Current Approach

• ORDA Build 10 & 12
  – Static ground clutter maps (BYPASS map)
  – Operator-defined Clutter Censor Zones (CCZ)

• ORDA Build 11
  – Lower tilts (split cuts)
    • Clutter Mitigation Decision (CMD)
  – Upper tilts
    • Static ground clutter maps (BYPASS map)
  – Operator-defined Clutter Censor Zones (CCZ)

CMD is good!
Ground Clutter Detection

Clutter Mitigation Decision (CMD)

- Uses temporal and spatial features in a fuzzy-logic system to automatically detect ground clutter contamination in real time
  - Detections are “filled-in” using spatial filter
  - Requires filtered and unfiltered data
  - Functionality split between RVP-8 and RCP-8
Ground Clutter Filtering
Gaussian Model Adaptive Processing (GMAP)

- Uses Gaussian model for clutter to determine notch width
  - Suppression is limited by maximum notch width
- Needs Blackman window to achieve required suppression
  - Does not produce data with best possible quality
- Uses iterative process to reduce reflectivity bias
  - Computationally intensive
- Needs at least 16 samples to achieve required suppression
  - Imposes limit on faster updates
- Not conducive to more spectral processing
  - Phase is lost from filtered signal
  - Affected by circular convolution biases
- Algorithm is under Vaisala control

The CLEAN-AP Filter (I)

- CLEAN-AP is **automatic**
  - No need for user intervention
  - Real-time detection
  - No need for clutter maps

- CLEAN-AP produces data with the **best possible quality**
  - Adaptive data windowing finds the best compromise between clutter suppression and data quality

- CLEAN-AP meets NEXRAD **requirements**
  - Improved suppression (not limited by max. notch width)
  - Requirements (Z) met with as little as 8 samples

- CLEAN-AP is **integrated**
  - One algorithm for ground clutter detection and filtering
  - Gate-by-gate operation
The CLEAN-AP Filter (II)

- **CLEAN-AP** “sets the stage” for further **spectral processing**
  - Phase information is not lost
  - Immune to biases from circular convolution

- **CLEAN-AP** is **operational on the NWRT PAR**
  - Running in real-time since Sep 2008
  - Performance informally evaluated by meteorologists and forecasters (PARISE experiments)

- **CLEAN-AP** consideration as an alternative clutter mitigation solution **makes sense now**
  - Re-implementation of an automatic ground clutter detection scheme will be needed after ORDA B12
  - In principle, compatible with dual pol., SZ-2, and SPRT
How does CLEAN-AP work? (1)

The “lag-1 autocorrelation spectral density” (ASD)
How does CLEAN-AP work? (II)

Integrated detection and filtering

- Estimate CNR
- Select appropriate data window
- Compute ASD
- Identify components with clutter contamination
  - Phase of ASD is near zero due to leakage effect

Detection

Filtering

- Remove clutter
- Interpolate weather

- ASD is used to estimate spectral moments directly

\[ |\text{ASD}| \]

\[ \text{DC} \]

\[ \text{Arg(ASD)} \]

zero phase

\[ v \]

\[ v \]
CLEAN-AP vs. Current Approach

CLEAN-AP Moment Comp. vs. Current Approach Moment Comp.

RVP-8

I/Q
Doppler Spectra ➔ CLEAN-AP ➔ Moment Comp. ➔ Z

CMD Flags
Clutter Det. Flags

RVP-8

I/Q
Doppler Spectrum ➔ GMAP ➔ Moment Comp. ➔ Z

S_r ➔ Moment Comp. ➔ Z_r
S_u ➔ Moment Comp. ➔ Z_u

RCP-8

CMD Data Sorting ➔ Z
Summary and 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