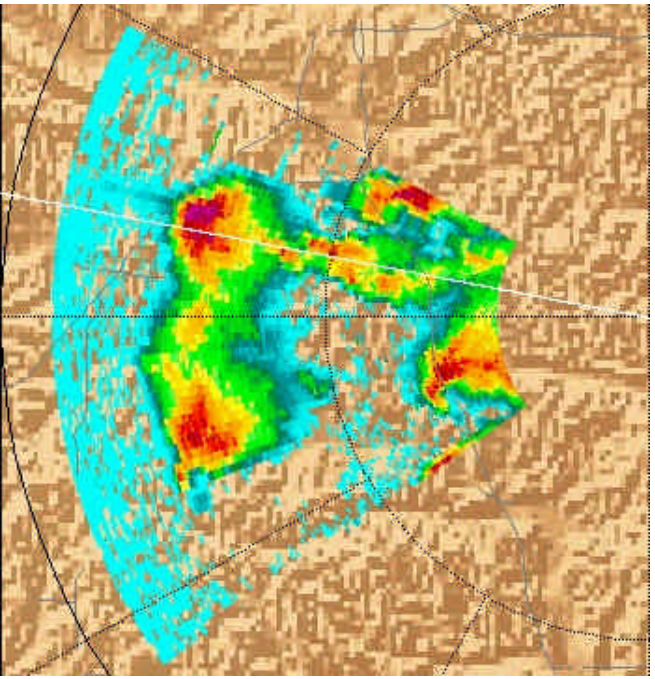
RADAR OPERATIONS CENTER (ROC) EVALUATION OF THE WSR-88D OPEN RADAR DATA ACQUISITION (ORDA) SYSTEM SIGNAL PROCESSING



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WSR-88D Radar Operations Center
Engineering Branch

Evaluation Focus

- Spectrum Width Estimators
  - Legacy Style (R0/R1)
    - Signal plus Noise
    - Noise Compensated
  - "Lag Two" (R1/R2)
  - Bias and Standard Deviation Performance
- New Clutter Filters
  - **GMAP** - Gaussian Model Adaptive Process
    - Bias
    - Standard Deviation
    - Suppression
    - Processing Windows
    - Comparison to Legacy Performance

→ **Phase 1: Simulations**
Phase 2: Real Data (Archived)

Simulation Methodology

SIGMET
RVP8
(and Utilities)

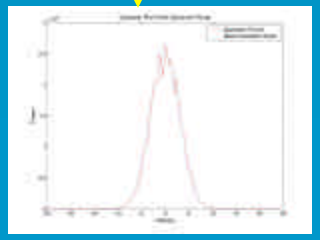
A'scope
Dig Sig Sim
Recorder

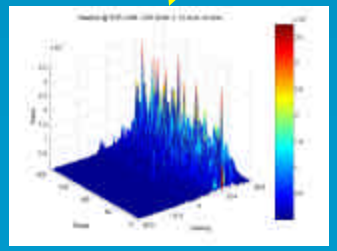
MATLAB

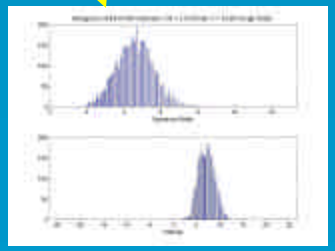
File conversion
Histograms
3-D plots
Calculations

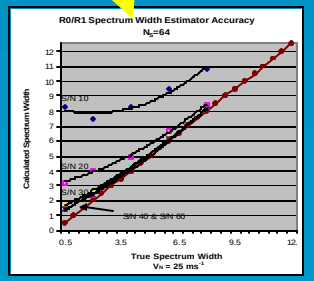
MS
EXCEL

Spreadsheets
Graphs









Primary Simulation Parameters

- Spectrum Width
  - R0/R1 and R1/R2
  - PRF: 1000
  - N_S: 64
  - Width: 0.5 – 8.0 ms^{-1}
  - Nyquist Co-interval
  - SNR: 10 – 60 dB
  - Noise: -80 dBm
  - Clutter: off
- GMAP
  - R1/R2 SW Estimator
  - PRF: 322, 450, 1000
  - N_S: 16, 32, 64
  - Width: 4.0 ms^{-1}
  - SNR: 10 – 60 dB
  - CSR: up to 60 dB

4,000 estimates per run
200 spectra and time series each file
2400 + data files generated

Types of Spectrum Width Estimators

R0/R1 Estimator

Legacy, noise removed

$$W = \frac{\sqrt{2}V_a}{p}\left[\ln\frac{S}{R(T_s)}\right]^{1/2}$$

SIGMET, with noise

$$W_n = \frac{\sqrt{2}V_a}{p}\left[\ln\frac{S+N}{R(T_s)}\right]^{1/2}$$

$R(T_S)$ —— R_1

S, S+N —— R_0

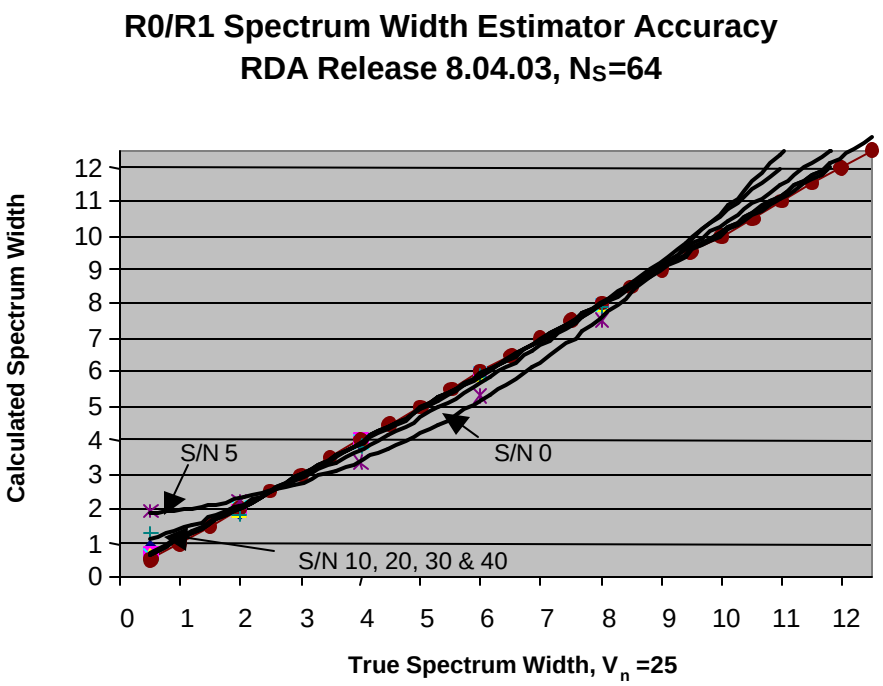
R1/R2 Estimator

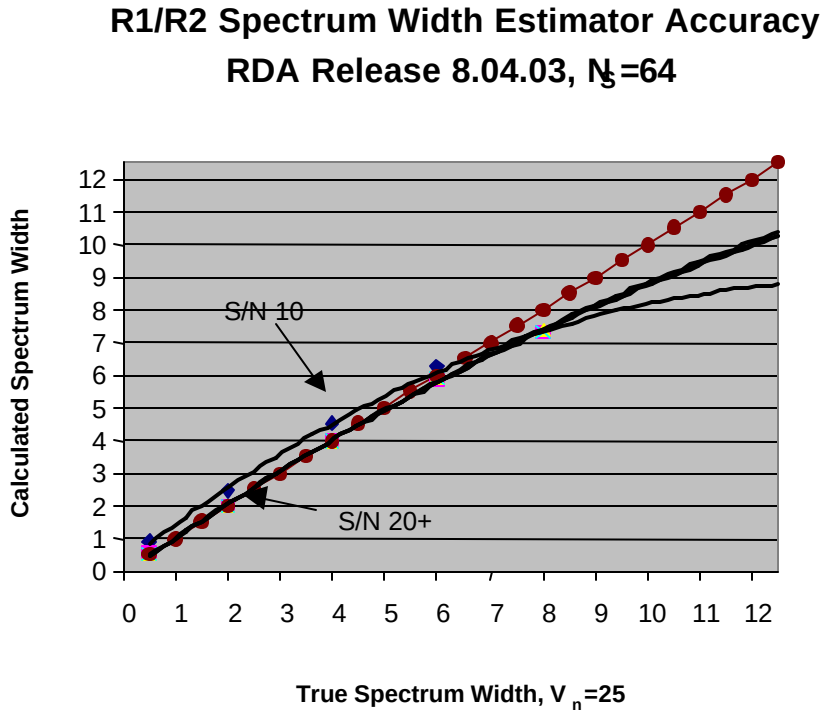
SIGMET Implementation

$$W = \frac{\sqrt{\text{variance}}}{p}$$

$$\text{variance} = \frac{2}{3}\ln\left[\left|\frac{R_1}{R_2}\right|\right]$$

Width Estimator Bias Performance

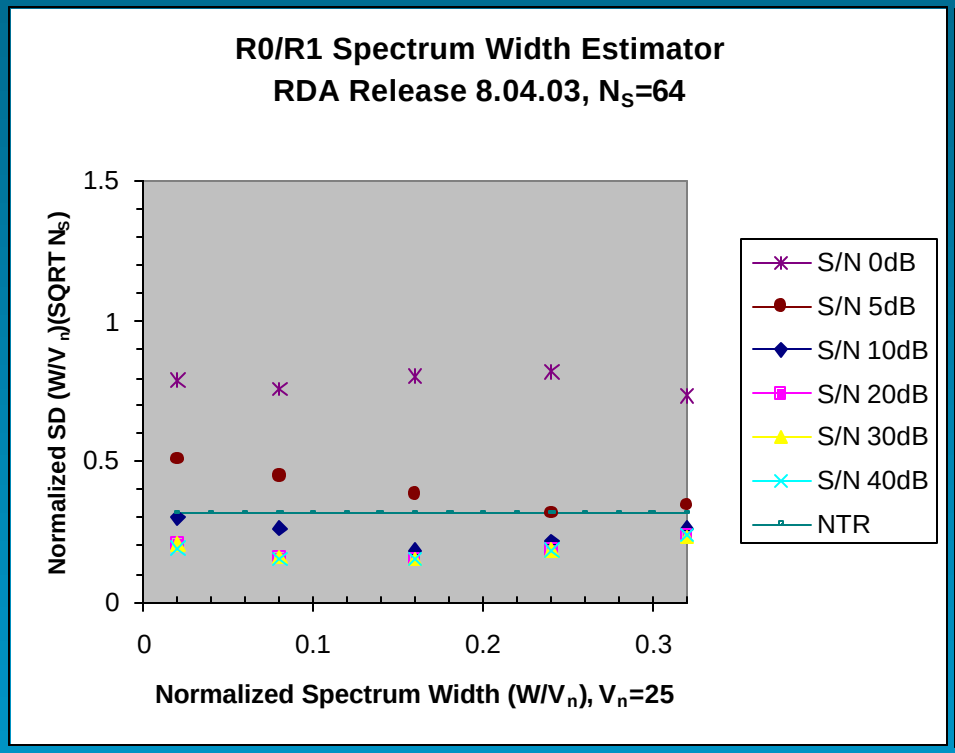


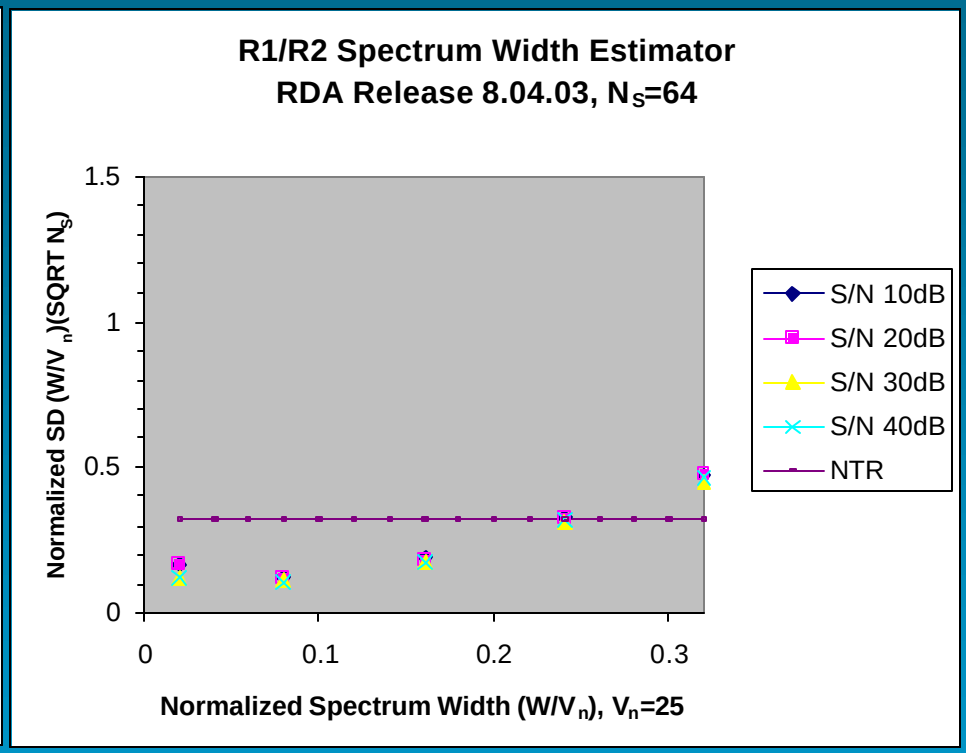


R0/R1

R1/R2

Width Estimator Standard Deviation

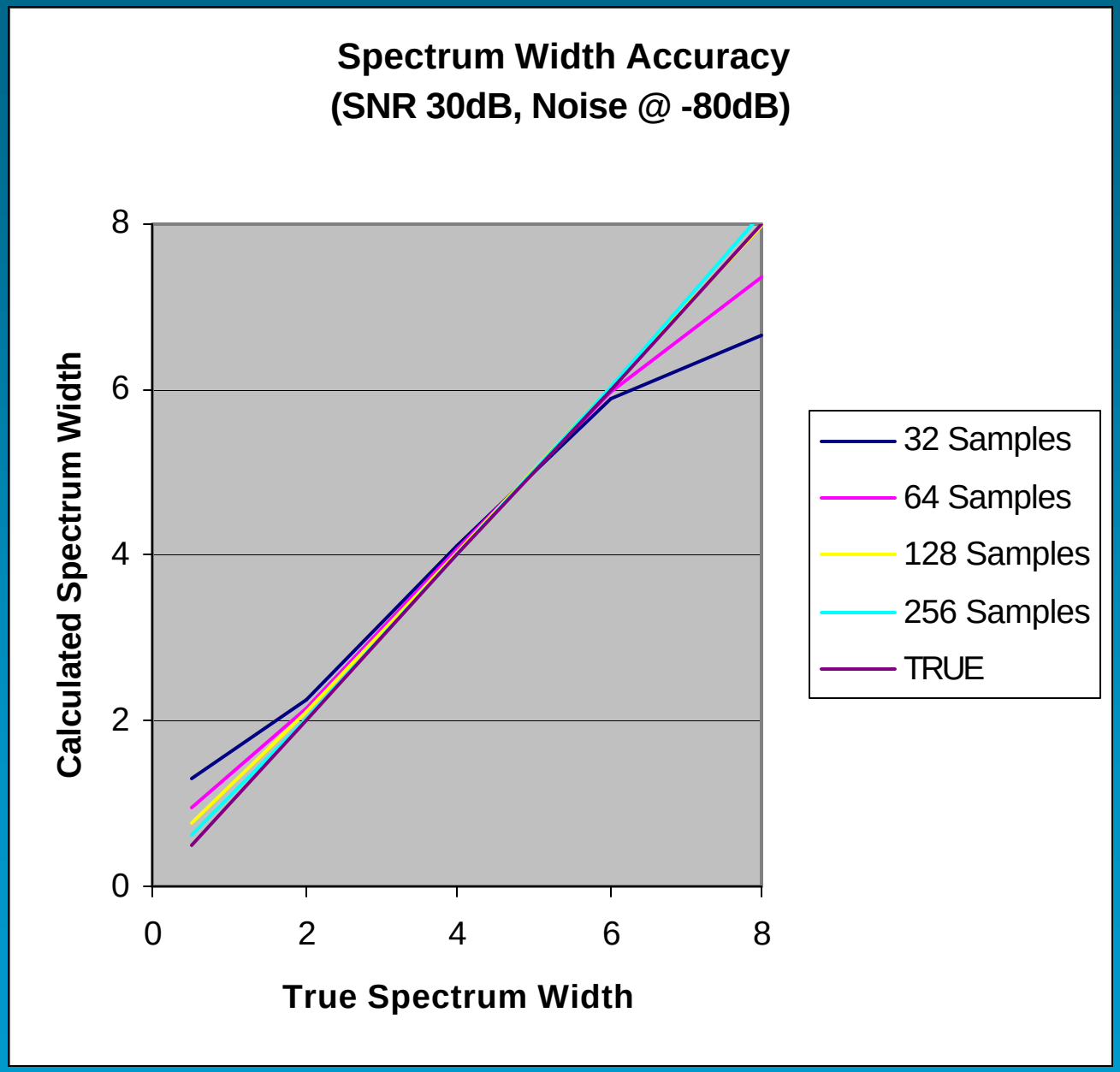




R0/R1

R1/R2

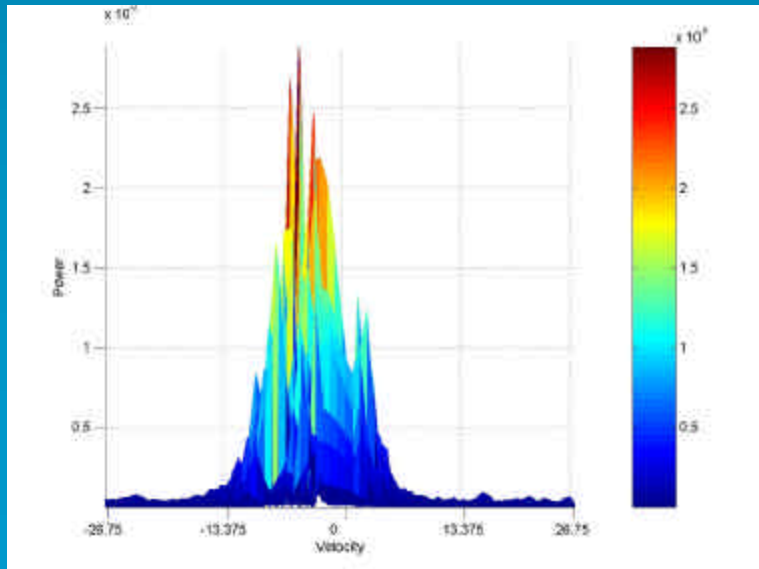
R1/R2 Width Estimator Number of Samples Bias

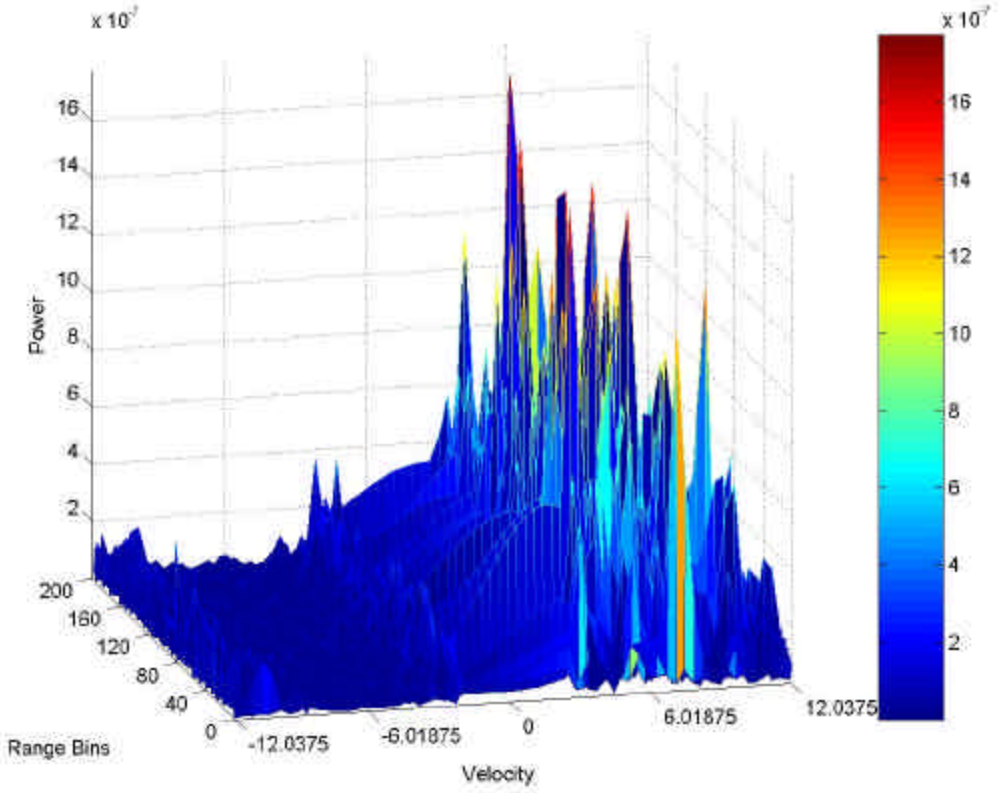


GMAP Overview

- Not a notch width based scheme
- Frequency domain signal, clutter, and noise analysis
- Uses best window (Blackman, Hamming, Rectangular)
- Models the clutter based on single input parameter
  - expected clutter spectrum width (0.28 m/sec for example)
- Uses system value or a rank order noise estimate
- Removes clutter associated spectral coefficients
- Restores signal spectral coefficients
- Estimates performed in time domain

Reduces filter bias effects

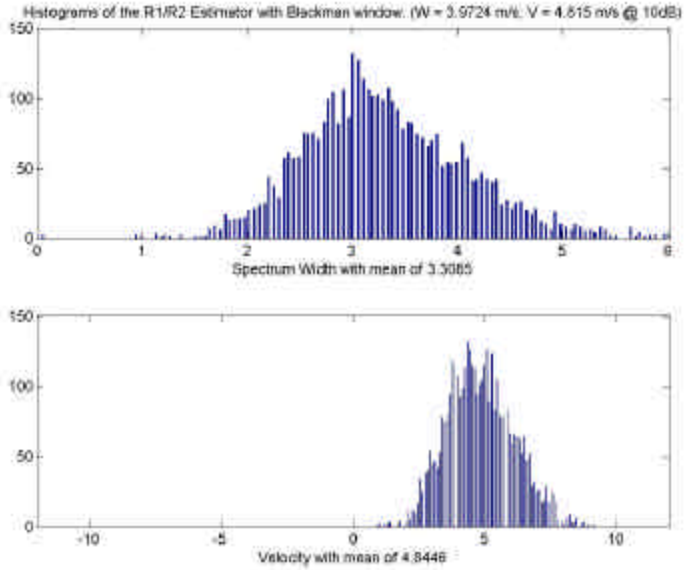




200 Spectra Showing Coefficient Restoration

10 dB SNR
PRF 450, CSR 50 dB
V = 4.8 ms^{-1}
W = 4.0 ms^{-1}

Histogram of 4,000 Velocity and Width Estimator Outputs



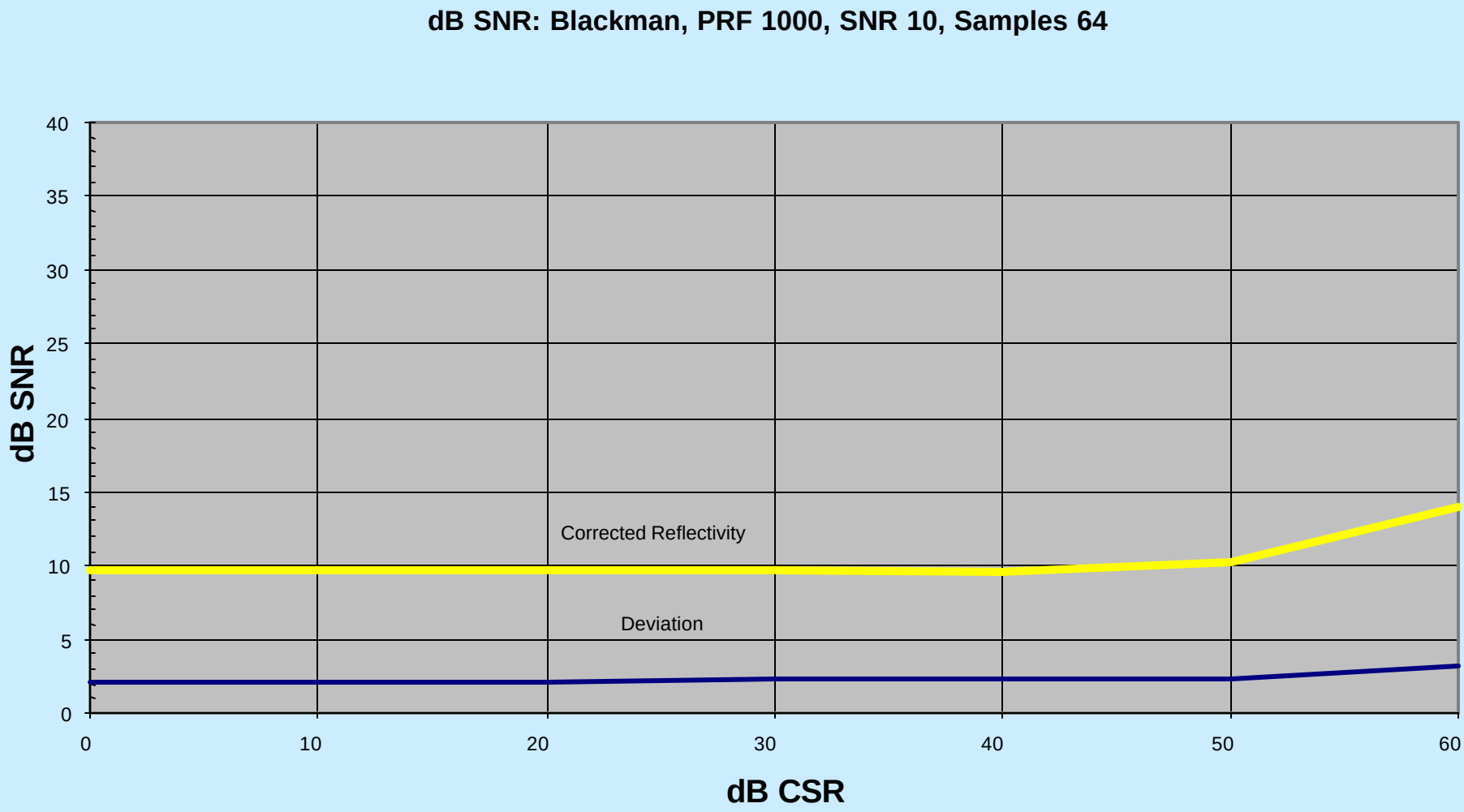
Surveillance Data – Reflectivity; N = 16, SNR = 10 dB
GMAP Performance - Blackman Window - System Noise as an Input

	CSR= 10 dB		CSR = 30 dB		CSR = 50 dB	
V/V_n	P_{bias} (dB)	SD[P] (dB)	P_{bias} (dB)	SD[P] (dB)	P_{bias} (dB)	SD[P] (dB)
0.0	-0.91	2.85	-1.13	3.29	0.60	3.14
0.1	-0.99	2.91	-1.06	3.36	-0.43	3.18
0.2	-0.88	2.82	-1.24	3.37	-0.43	3.21
0.3	-0.90	2.84	-1.01	3.11	-0.24	3.04
0.4	-0.95	2.71	-0.89	2.94	-0.16	3.05
0.5	-0.70	2.64	-0.8	2.78	-0.17	2.95
0.6	-0.65	2.51	-0.56	2.75	0.21	2.90
0.7	-0.46	2.46	-0.46	2.5	0.45	2.87
0.8	-0.41	2.42	-0.31	2.45	0.59	2.76
0.9	-0.25	2.27	-0.25	2.31	0.68	2.76
1.0	-0.25	2.31	-0.24	2.34	0.64	2.65
Averages	-0.67	2.54 dB	-0.72	2.84 dB	0.16	2.96 dB
Avg 1 km		1.27 dB		1.42 dB		1.48 dB

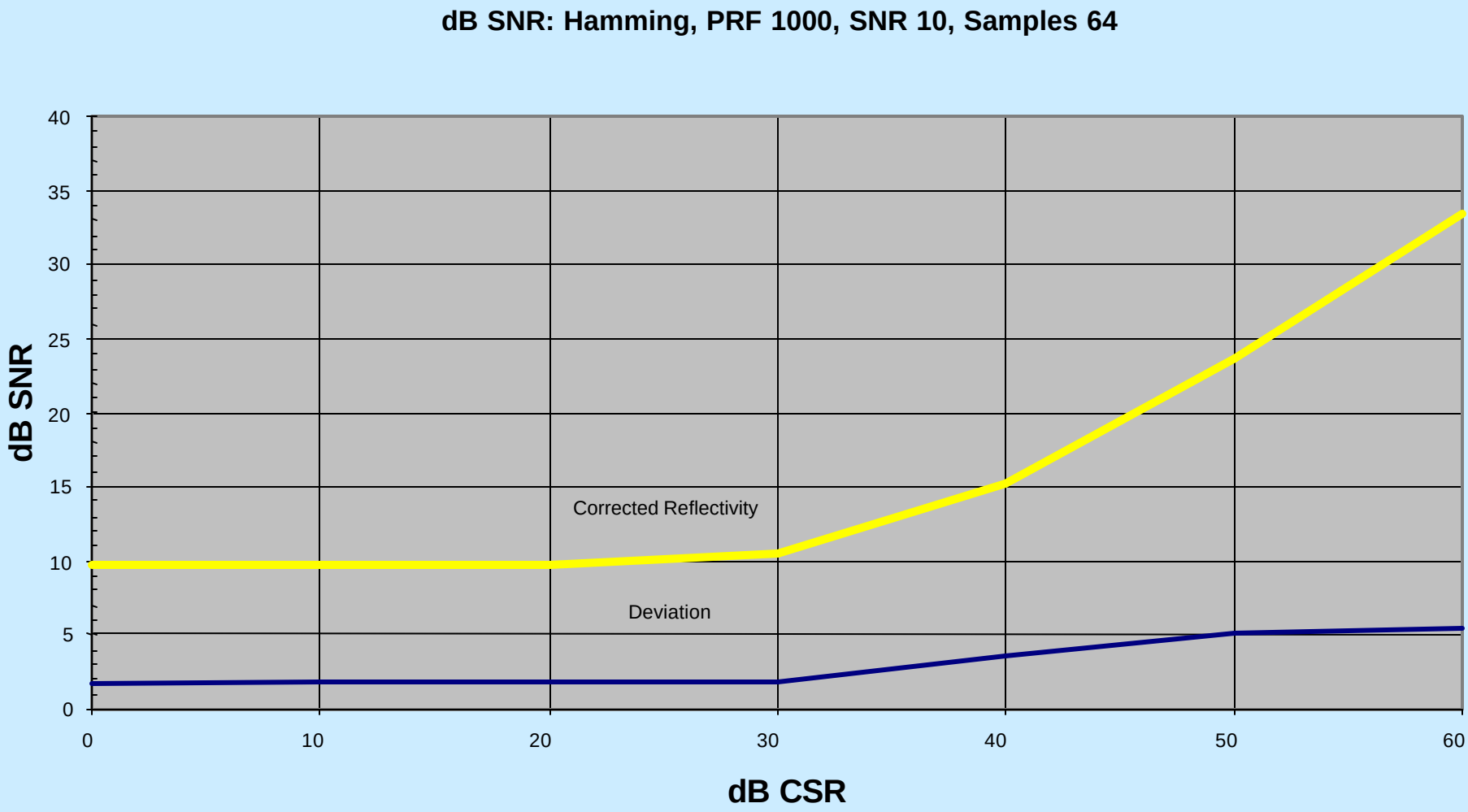
Doppler Data – Velocity; N_S = 32, SNR = 10 dB
GMAP Performance - Blackman Window - System Noise as an Input

	CSR= 10 dB		CSR = 30 dB		CSR = 50 dB	
V/V_n	V_{bias} (m/sec)	SD[V] (m/sec)	V_{bias} (m/sec)	SD[V] (m/sec)	V_{bias} (m/sec)	SD[V] (m/sec)
0.0	-0.01	2.12	-0.02	2.20	0.01	2.14
0.1	0.80	2.20	0.80	2.28	1.96	2.30
0.2	1.18	1.98	1.05	2.04	-0.43	2.30
0.3	0.51	2.01	0.51	2.04	-1.34	2.60
0.4	-0.03	1.96	0.01	2.01	-1.88	2.68
0.5	-0.07	1.88	-0.16	1.93	-1.93	2.95
0.6	-0.08	1.69	0.01	1.68	-1.61	2.95
0.7	0.05	1.58	0.02	1.66	-1.13	2.68
0.8	0.02	1.77	0.01	1.77	-0.86	2.95
Averages	0.26	1.91	0.25	1.96	-0.8	2.62

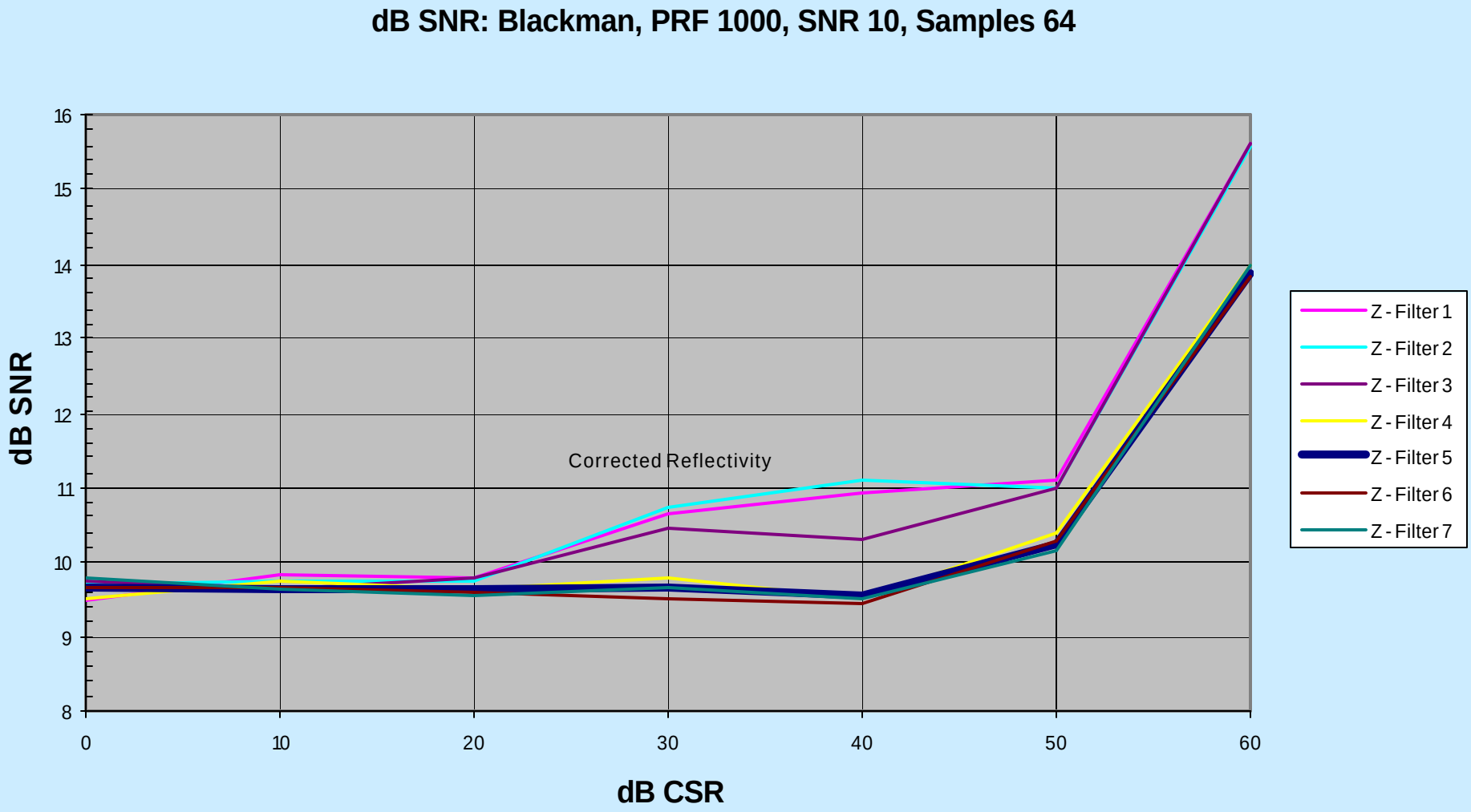
Suppression Level Analysis



Suppression Level Analysis



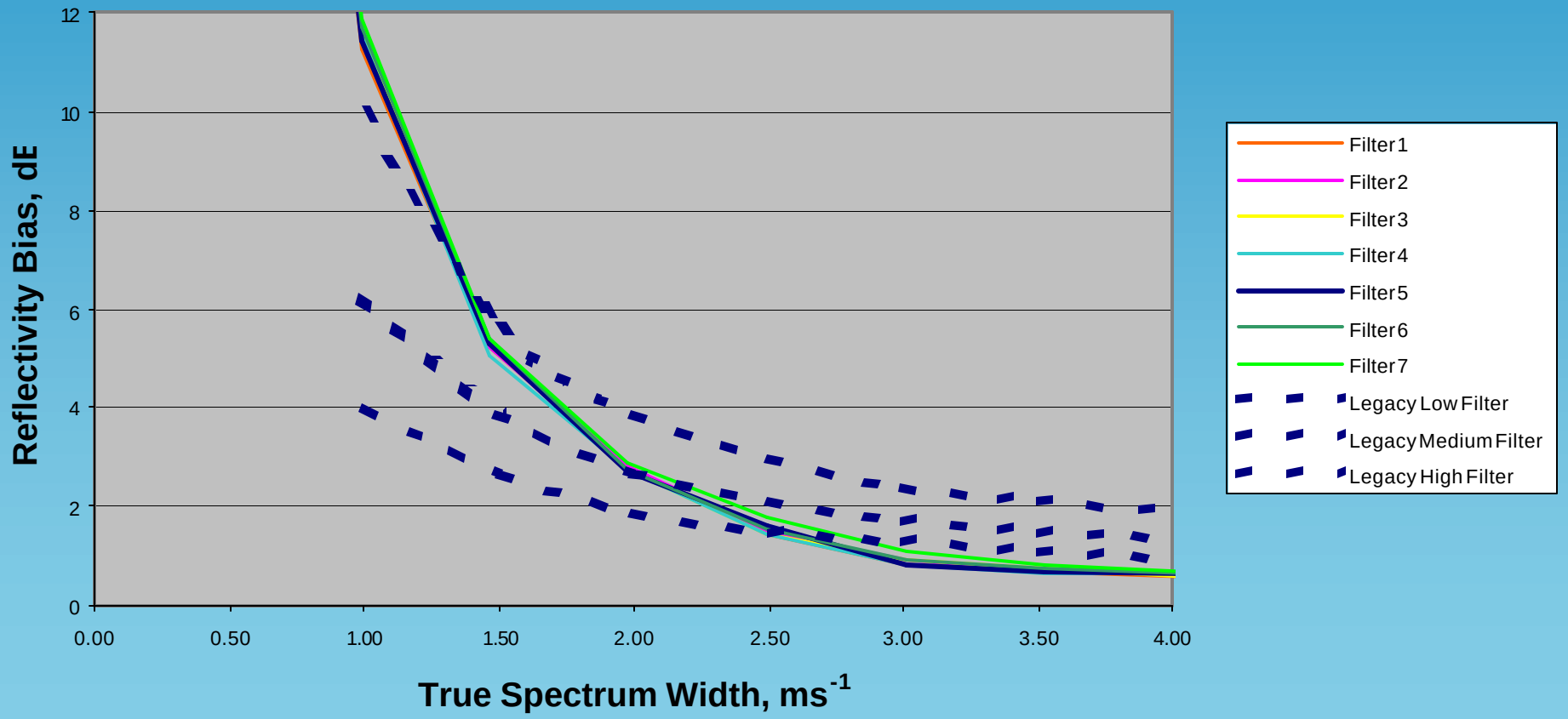
GMAP Filter Width Analysis



Reflectivity Bias Compared to Legacy Filters

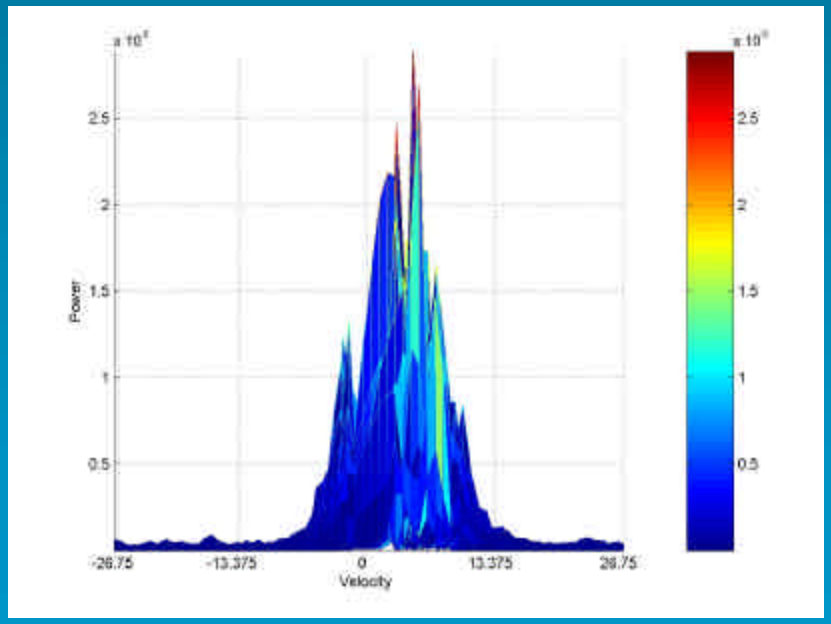
Performance in Zero Isotach in the Absence of Clutter

Surveillance, PRF 322, SNR 20 dB, No Clutter, 16 Samples, GMAP Filters 1-7, Reflectivity Bias vs Spectrum Width

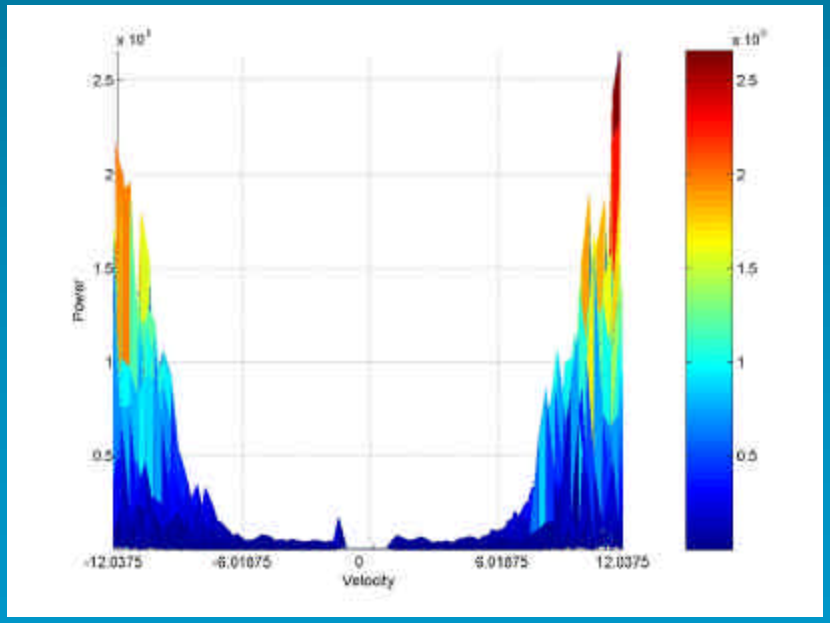


Loops Illustrating GMAP Weather Signal Restoration

Doppler



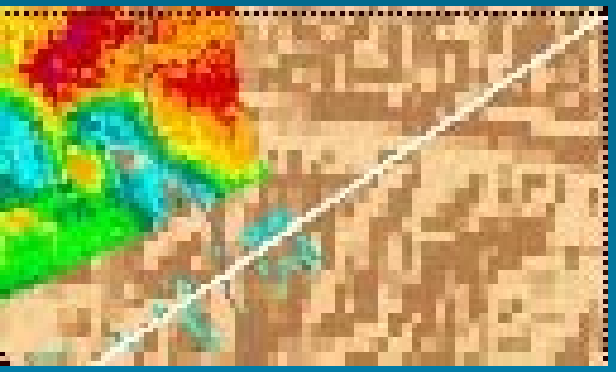
Clear Air



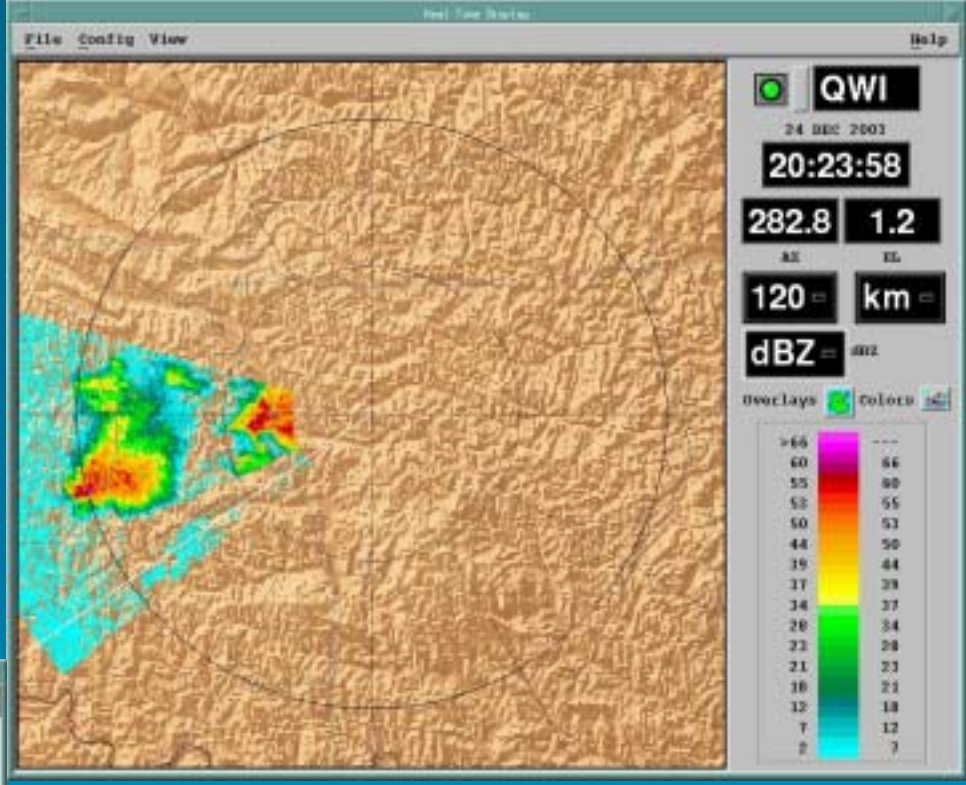
Conclusions from Simulations

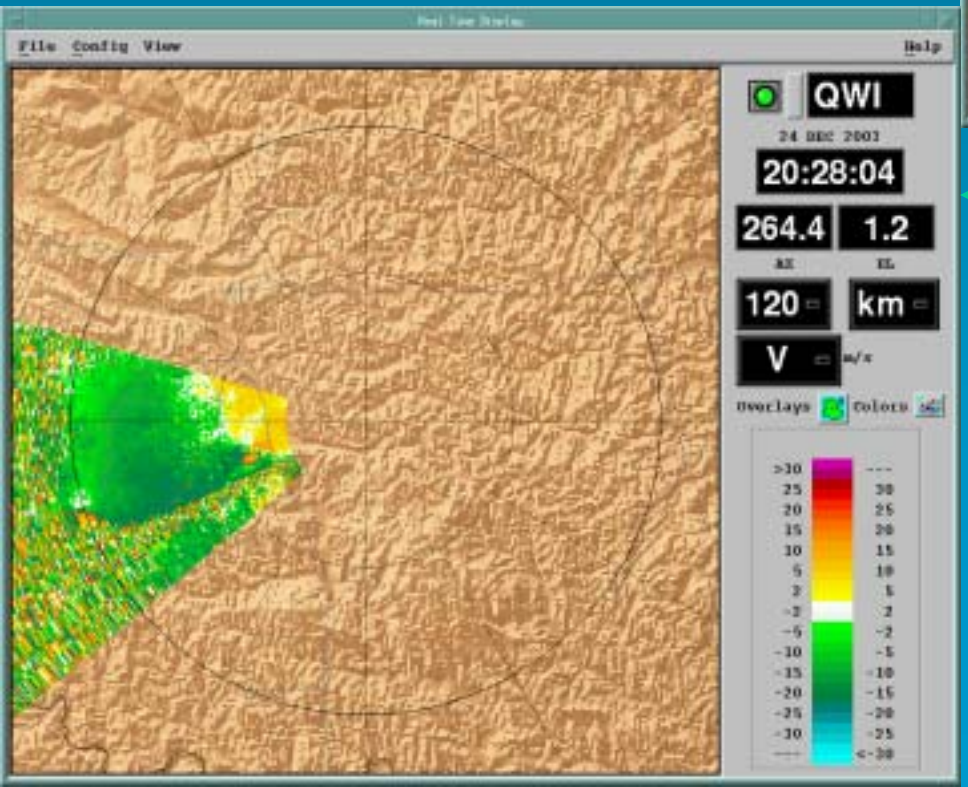
- **Width Estimators**
  - **Both Estimators Meet Specifications**
  - **R0/R1 Estimator Requires Accurate Noise Compensation**
  - **R1/R2 Has Advantages at Low SNRs and Narrow Widths**
  - **R0/R1 Has Less Bias at Higher Widths**
  - **R0/R1 Meets Variance Goal Over a Wider Range of Input Spectrum Widths**
- **Clutter Filters**
  - **GMAP Meets WSR-88D Specifications**
  - **Can Suppress Clutter up to 55 dB Above the Signal**
  - **Delivers Essentially Unbiased Estimates in the Presence of Clutter**
  - **Exhibits Higher Variance in Some Modes**
  - **Delivers Slightly Lower Bias than Legacy for Signals at Zero Velocity w/o Clutter**

RVP8 Playback from Legacy A1 Recorder Data, May 3, 1999 Storms

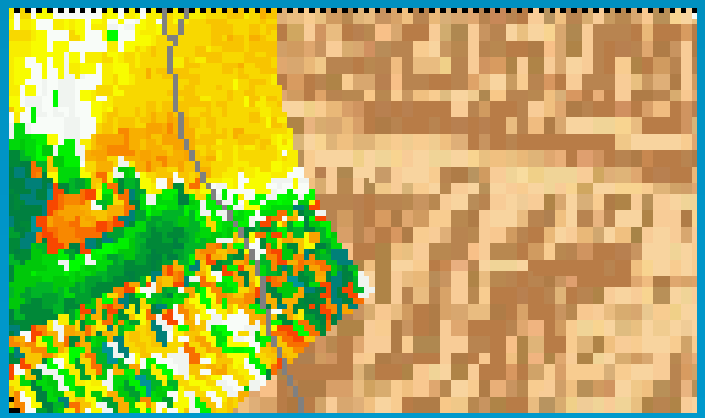


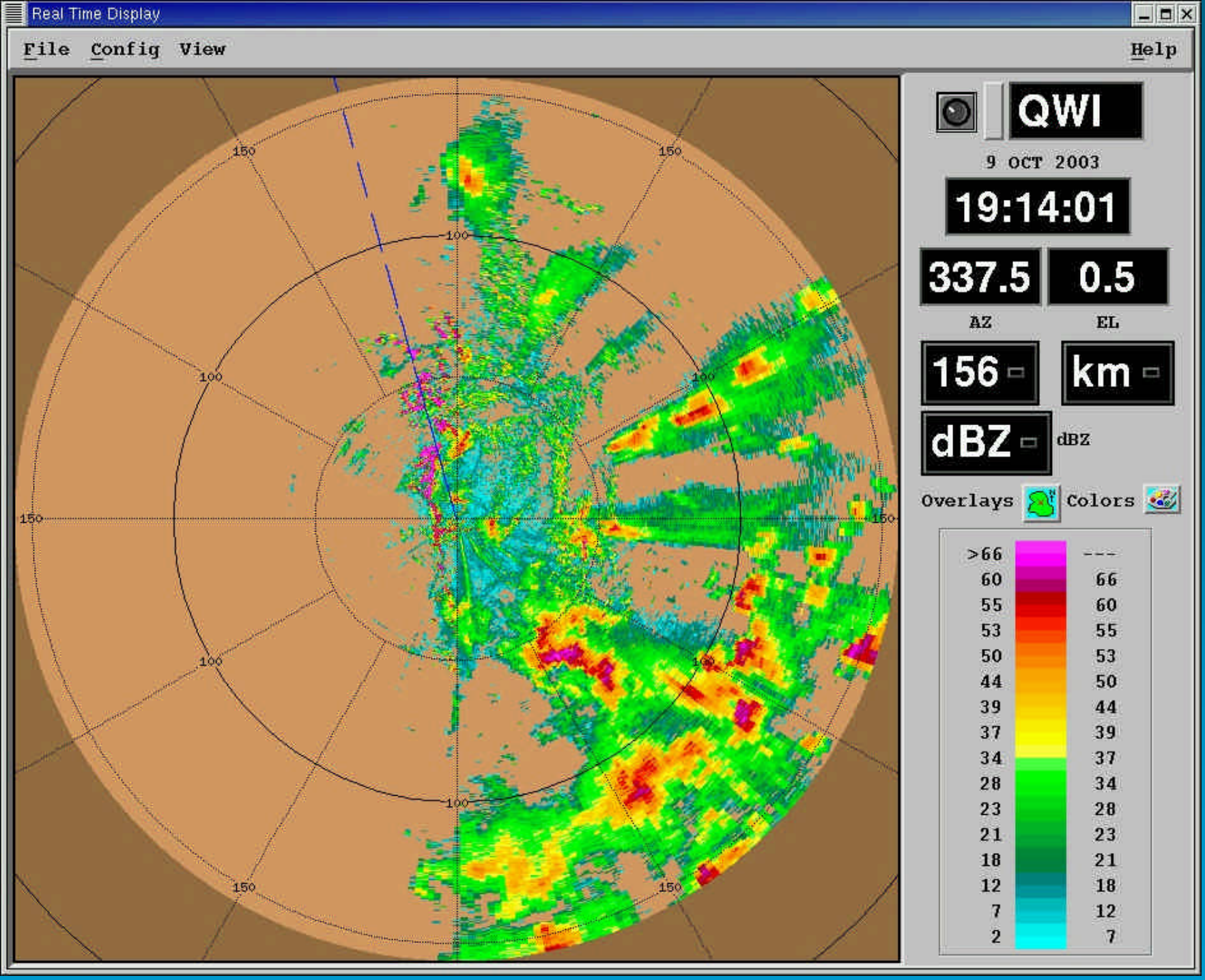
Reflectivity





Velocity

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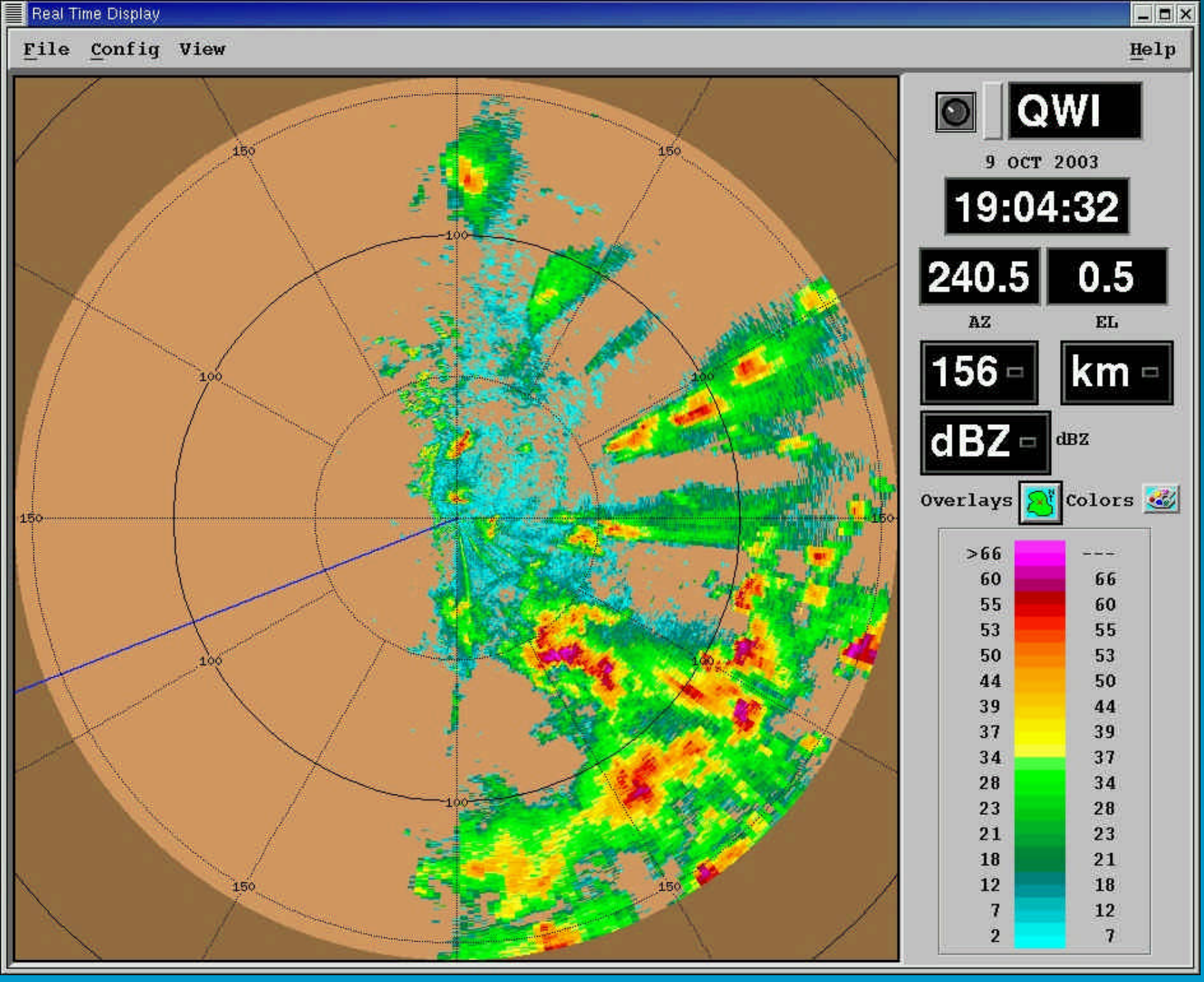
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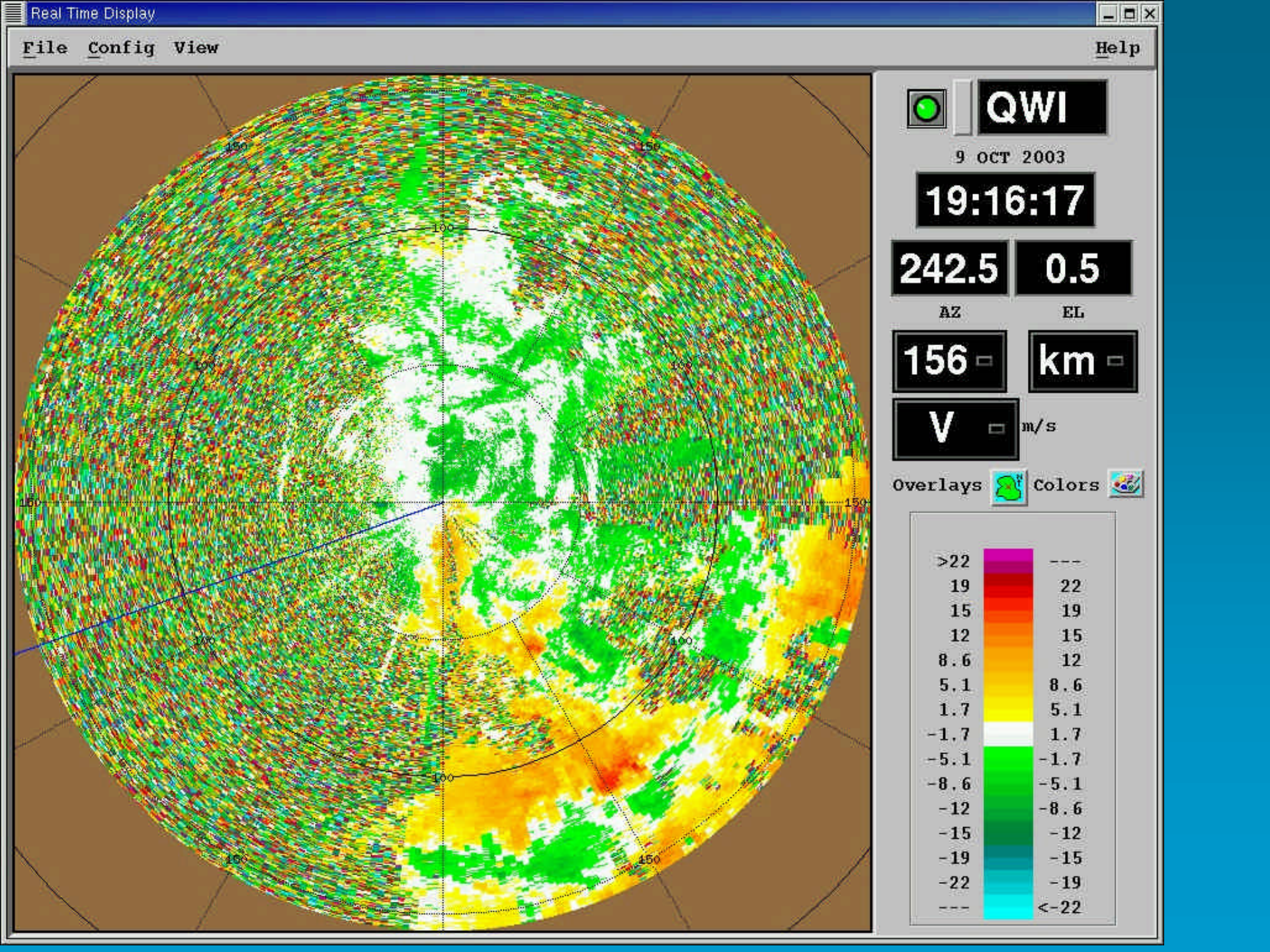
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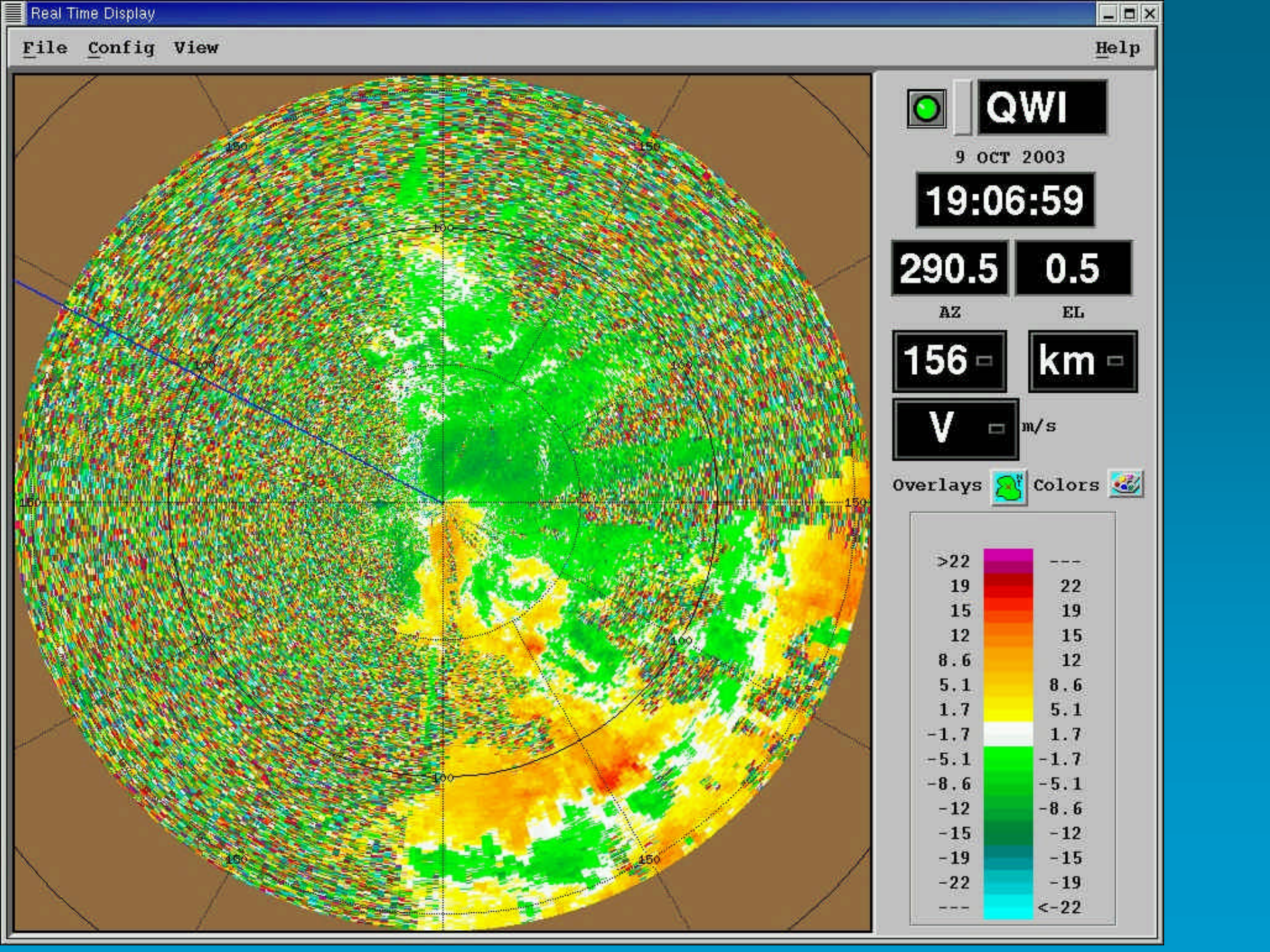
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