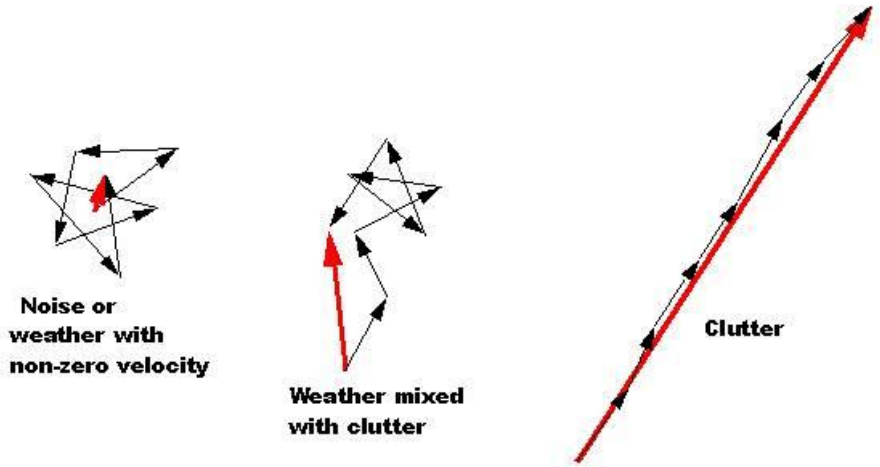
# CMD Deployment
## TAC Meeting, November 2009
### Rich Ice

- Review Implementation Design for Build 11.0
- Summarize Beta Test Results
  - Missed Detections
  - Resulting Build 11.1 Changes
- Build 11.1 Deployment
- On-going Field Performance Monitoring
  - CMD Performing Well in Most Cases
  - False Detections Associated with Low Mean Velocity Returns
  - Performance Examples
- Future Work

# CMD Algorithm - NCAR

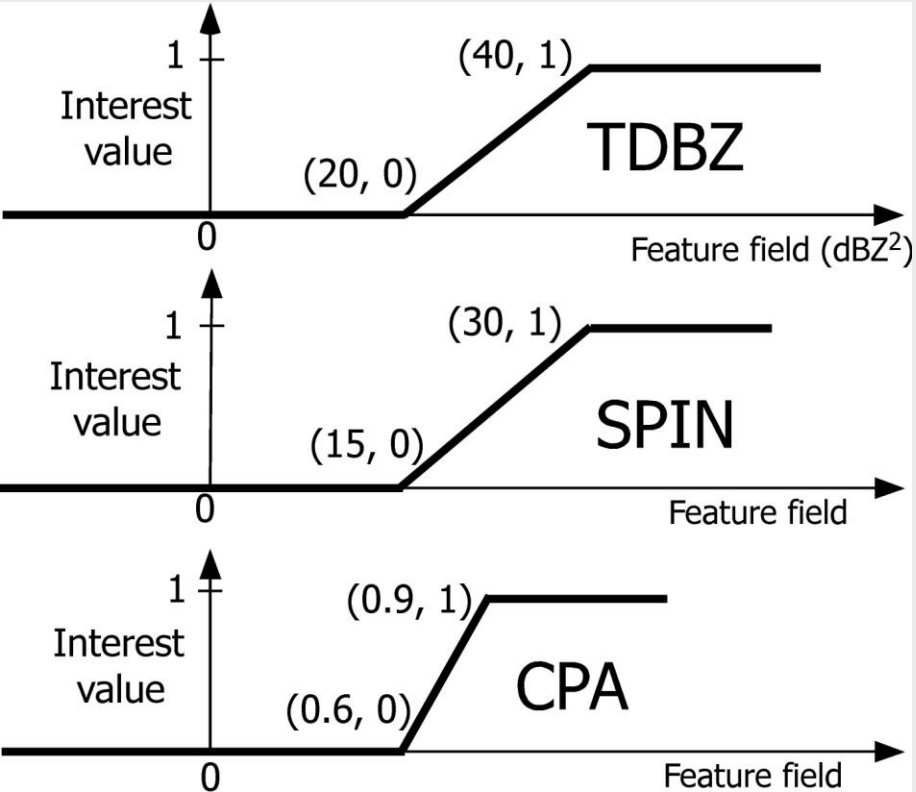
- Algorithm Feature and Fuzzy Logic Interest Fields
  - Clutter Phase Alignment (CPA)
  - Reflectivity Texture (single radial, 9 gates)
  - SPIN (single radial change of sign of texture gradient – 11 gates)
- Includes Data Quality Functions
  - Signal to Noise Ratio Threshold (currently 0 dB)
  - Fill in Filter (recommended 3 gates maximum)
  - Median Filter (recommended 3 gates for smoothing CPA)
- For algorithm design and performance details:
  - Hubbert, J. C., M. Dixon, S. M. Ellis and G. Meymaris, 2009a, Weather radar ground clutter. Part 1: identification, modeling, and simulation. J. Atmos. Oceanic Technol., 26, 1165-1180.
  - Hubbert, J. C., M. Dixon, S. M. Ellis and G. Meymaris, 2009b, Weather radar ground clutter. Part 2: Real-time identification and filtering,. J. Atmos. Oceanic Technol., 26, 1181-1197.

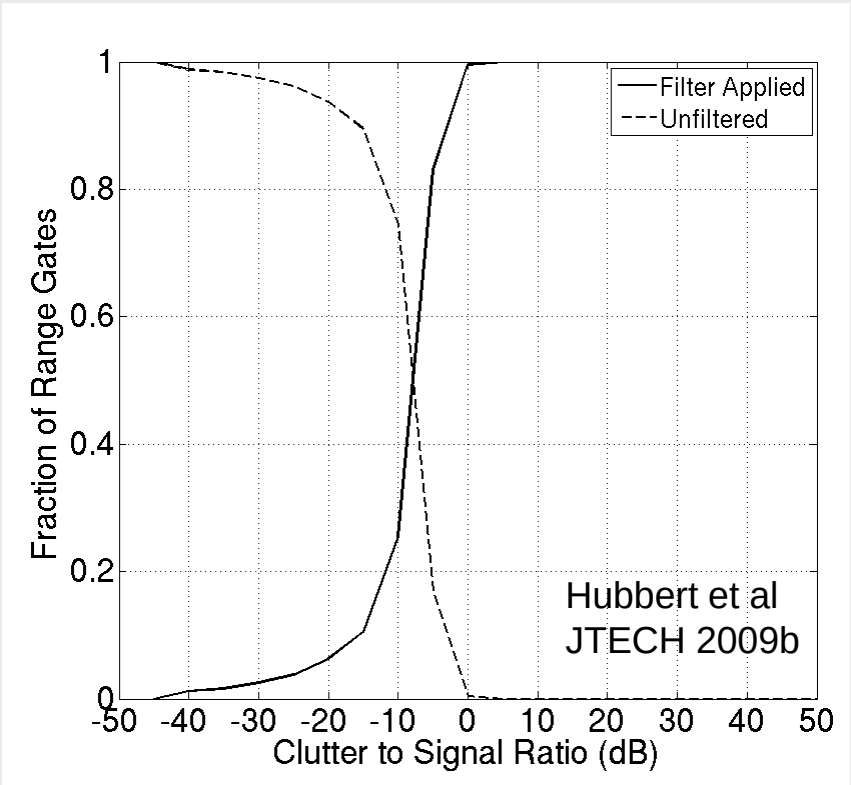
# A Few Details




Adding I and Q for a gate in a phasor diagram

$$CPA = \frac{\sqrt{\left(\sum_{i=0}^{m} I_i\right)^2 + \left(\sum_{i=0}^{m} Q_i\right)^2}}{\sum_{i=0}^{m} \sqrt{I_i^2 + Q_i^2}}$$



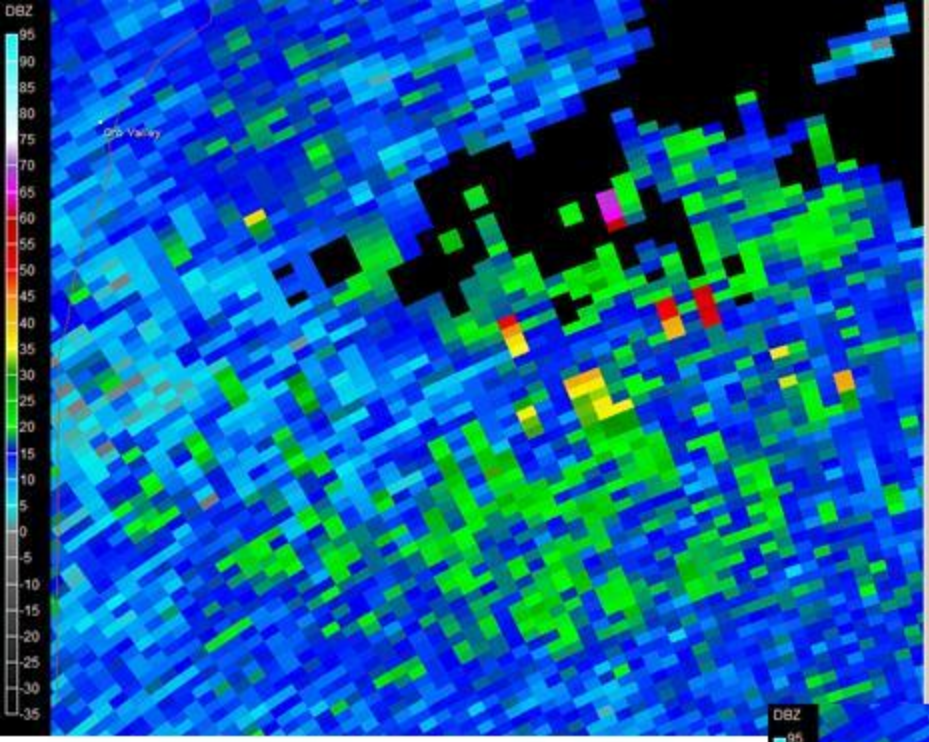



# CMD Implementation Design Features

- CMD Clutter Flags generated in RVP8
  - first Surveillance cut of each split cut segment (lower 2 of 5)
  - Super resolution: 0.5 degrees by 0.25 km
- CMD Parameters set by special configuration file
- Bypass Map to be same as baseline (1 deg by 1 km resolution)
- Surveillance Reflectivity filtered bins selected in near real time
  - Initially done on 0.5 degree by 1 km basis
  - Build 11.1 changed to Bypass Map application (more later)
- Doppler data filtered by normal application of bypass map
- Operator control – CMD enable/disable – can add zones
- Bypass map for each segment sent to RPG and in Level 2 data
  - Updated each volume
  - Associated with previous volume scan
- CMD Status indicator on HCI and in GSM

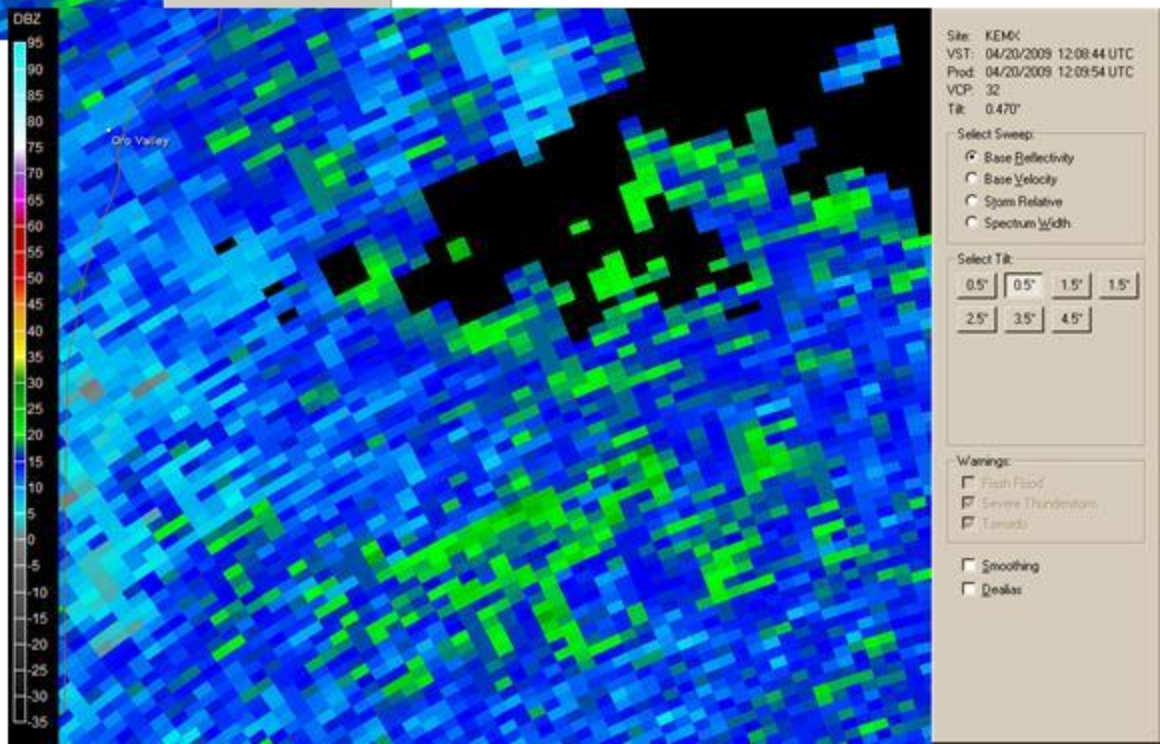
# Beta Tests – Spring – Summer 2009

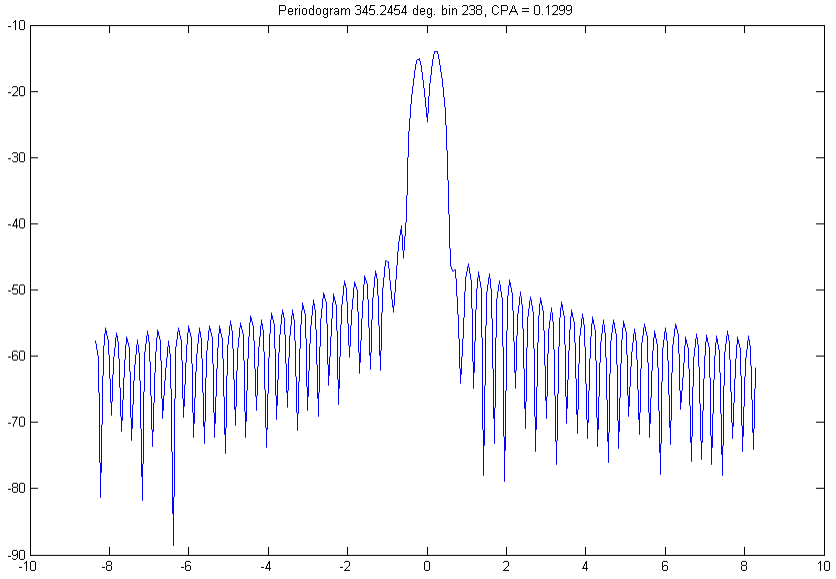
- Build 11.0 Beta Test – March 31 – May 14, 2009
  - Sites: Dodge City, Columbus AFB, Yuma, Tucson, South Kuai, Albuquerque, Sacramento
- Issue with missed detections seen initially at Tucson (KEMX)
  - Addressed in Build 11.1 Release with bypass map change
- Build 11.1 Beta Test – June 16 – July 21, 2009
  - Sites: Tucson, Albuquerque, Dodge City, Phoenix, Sacramento, Yuma
- Build 11.1 Deployment: July 27, 2009




**KEMX "Hot Spots" Surveillance Reflectivity**

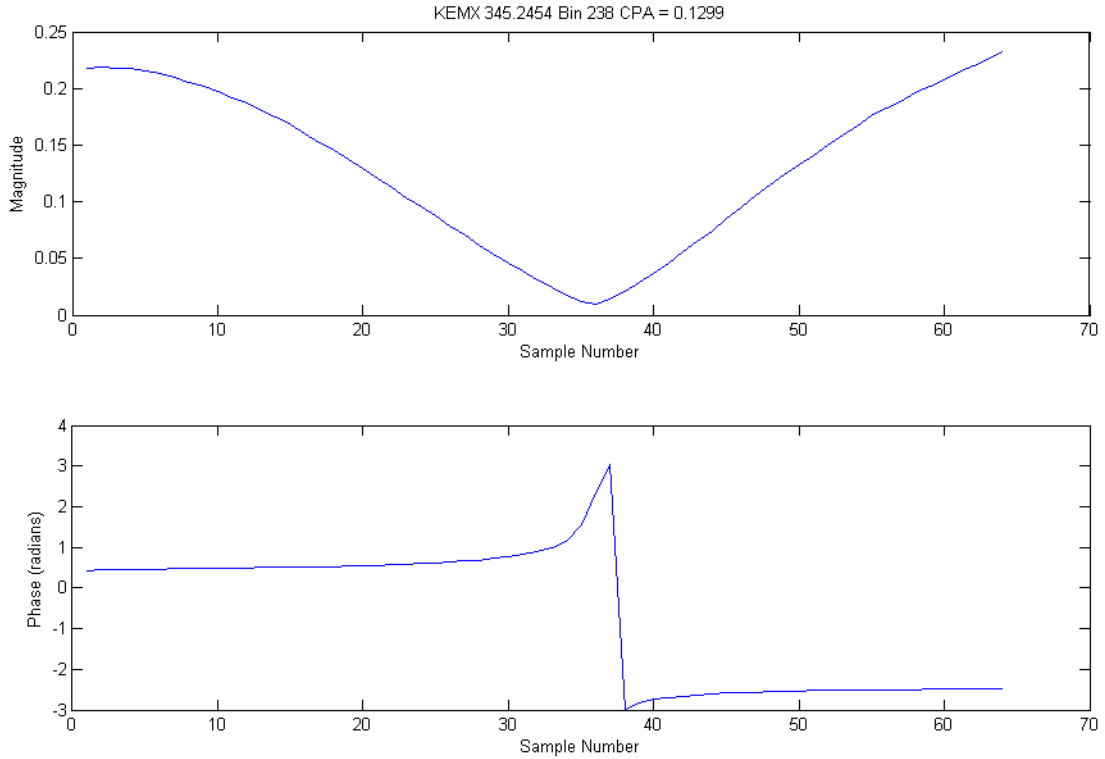
**KEMX Doppler Reflectivity**

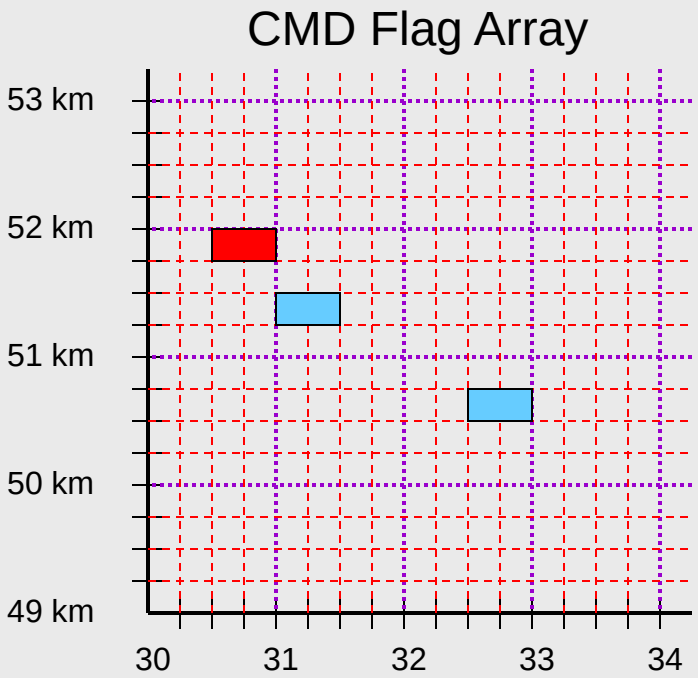





# Missed Detection Bin Spectral Characteristics

CPA = 0.1299



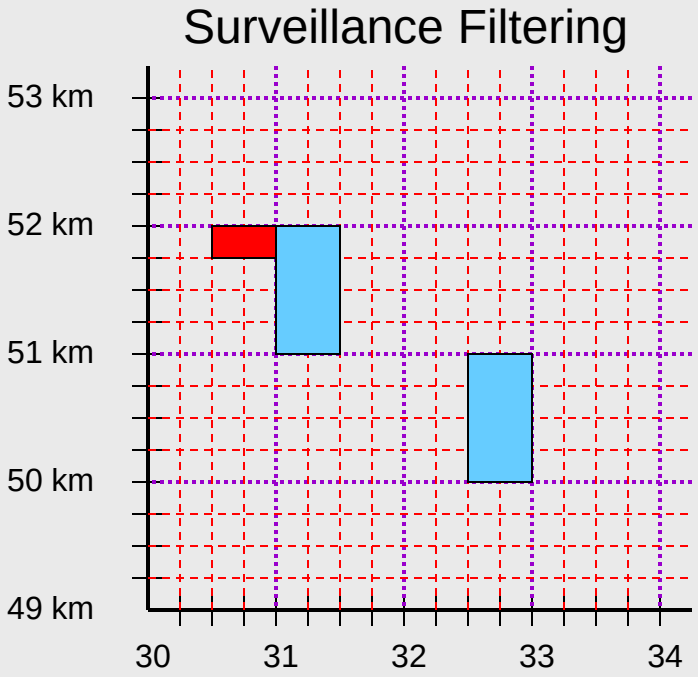


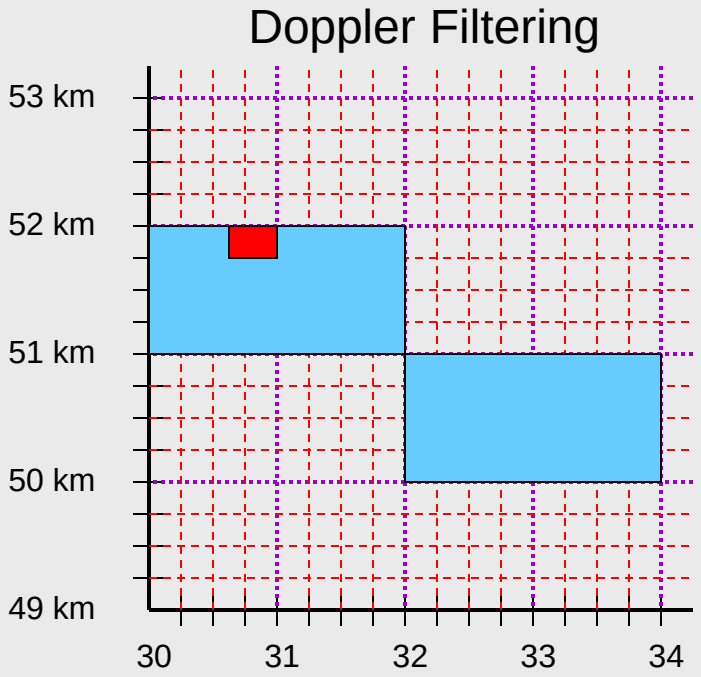

# Build 11.0 Design (Super Resolution):

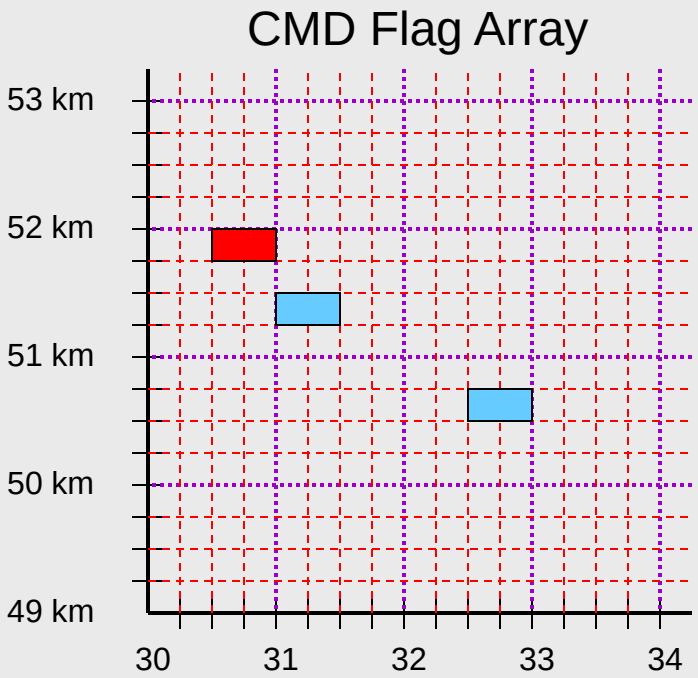
CMD Flags: 0.5 by 0.25 km

Surveillance Filtering: 0.5 by 1 km

Doppler Filtering: “Grown” Bypass Map



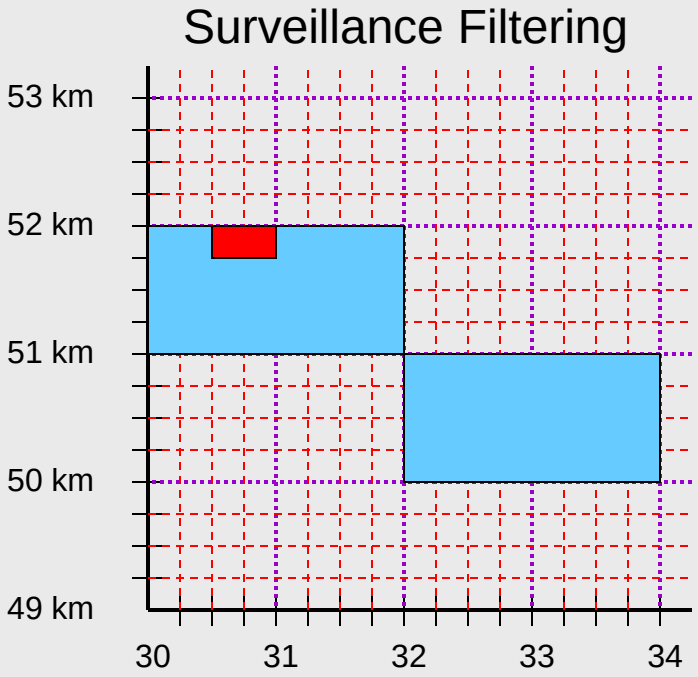


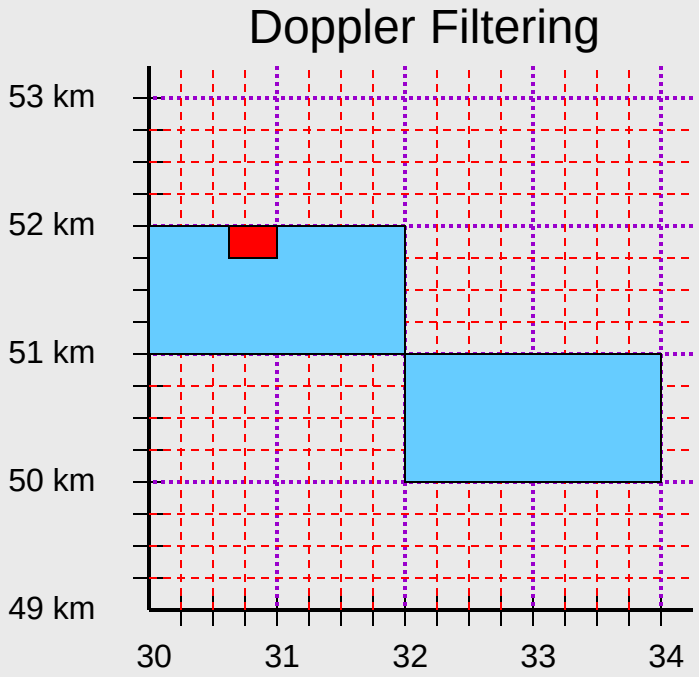

# Build 11.1 Design (Super Resolution):

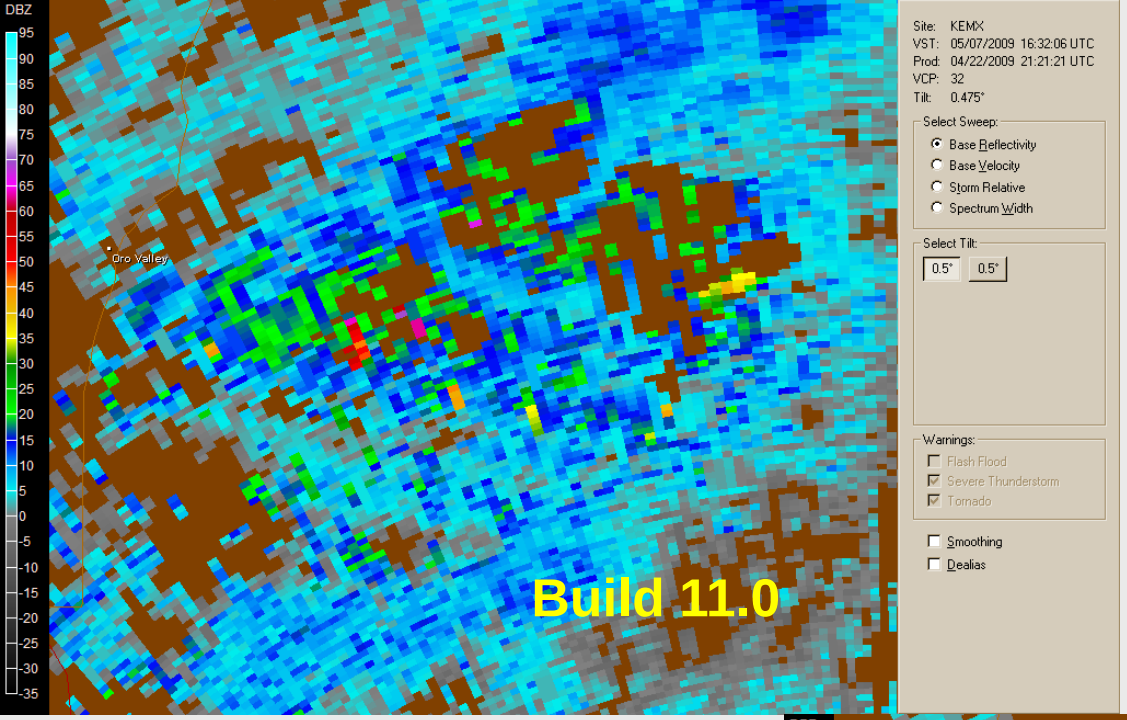
CMD Flags: 0.5 by 0.25 km

Surveillance Filtering: Bypass Map

Doppler Filtering: Bypass Map

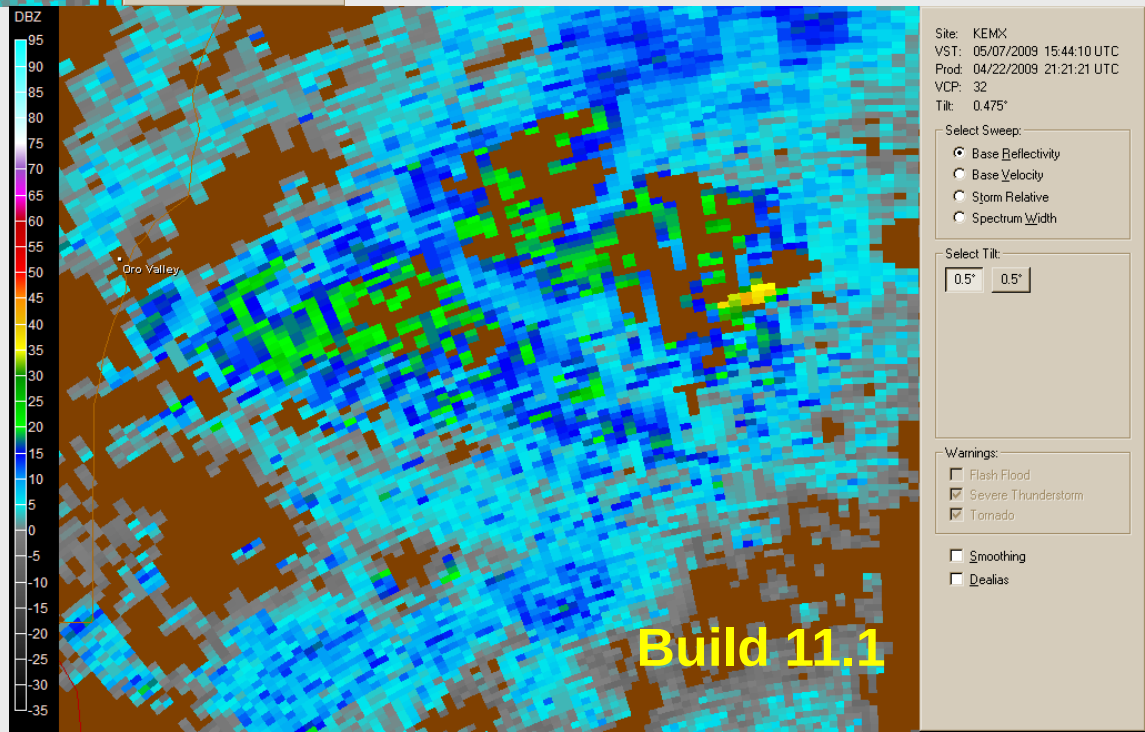




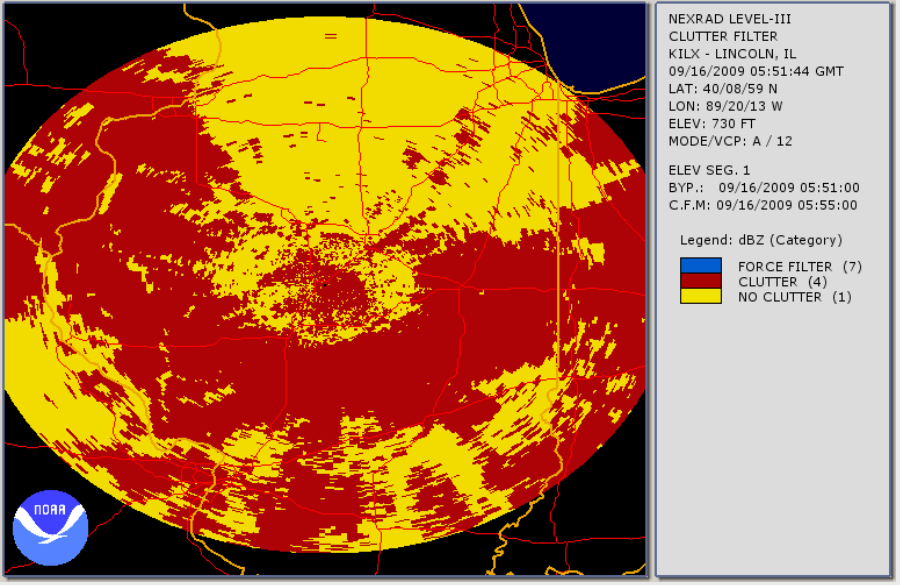

Good Results with Build 11.1

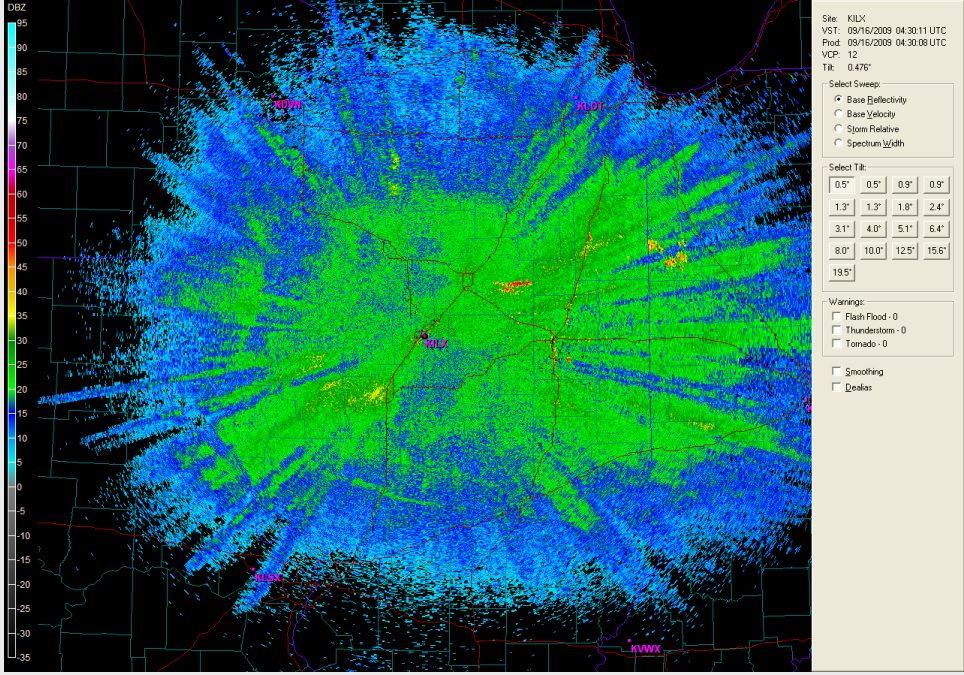
KEMX Replay Data



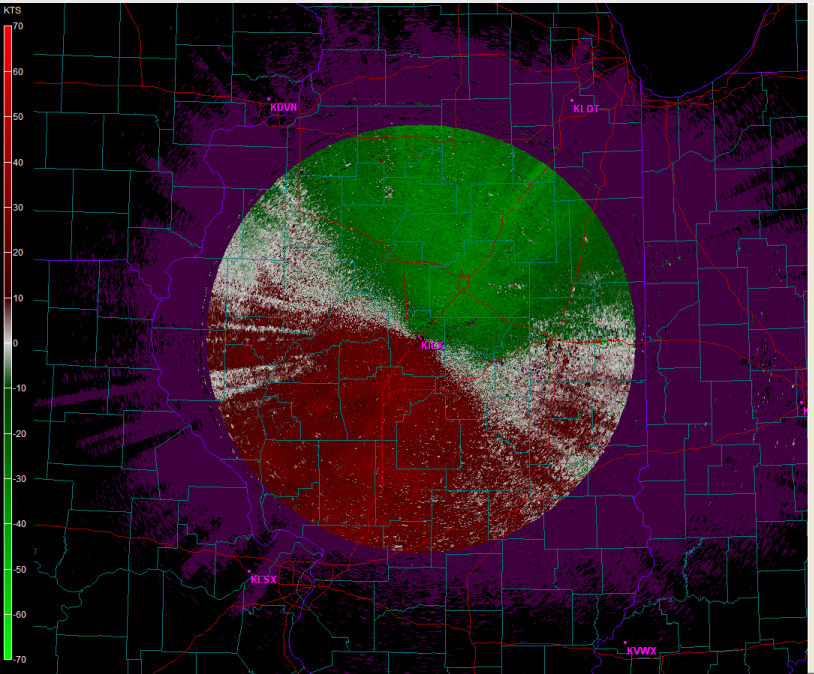
# Deployment Monitoring

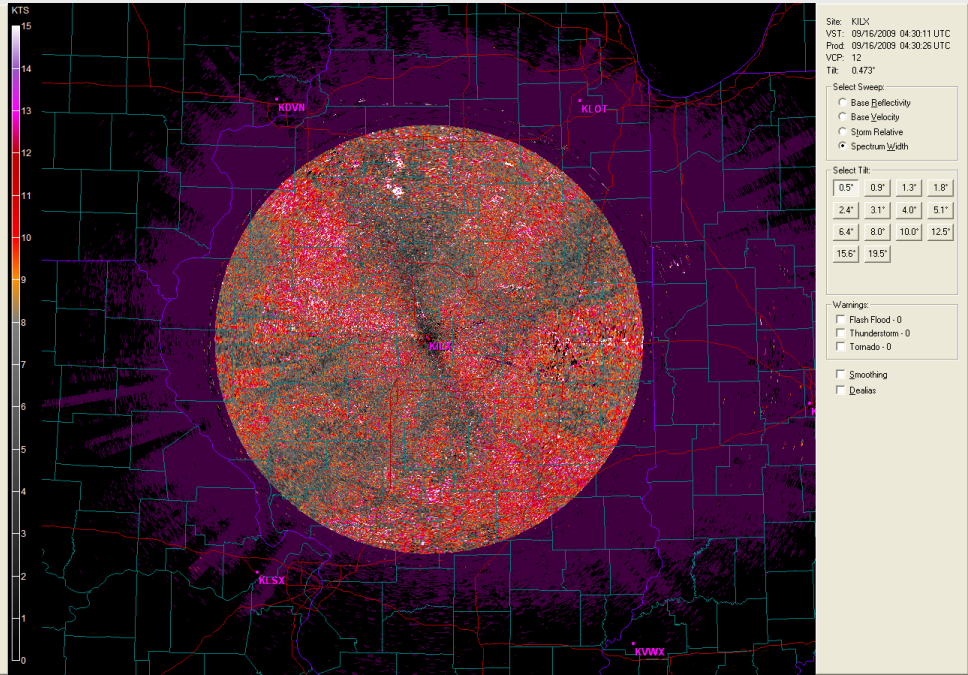
- CMD Active over most of the network
- Some ROC Hotline Calls
  - Some not CMD related
  - Several related to false detections in zero mean velocity regions
- CMD reveals AP clutter can change greatly over short time periods
- Examples follow



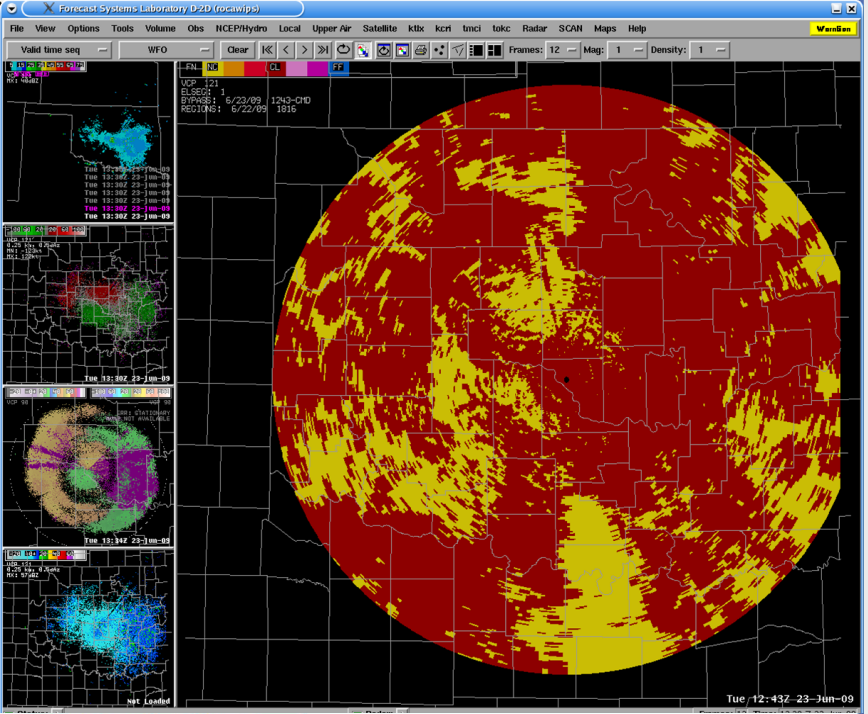

KILX 9/16/2009
Widespread AP

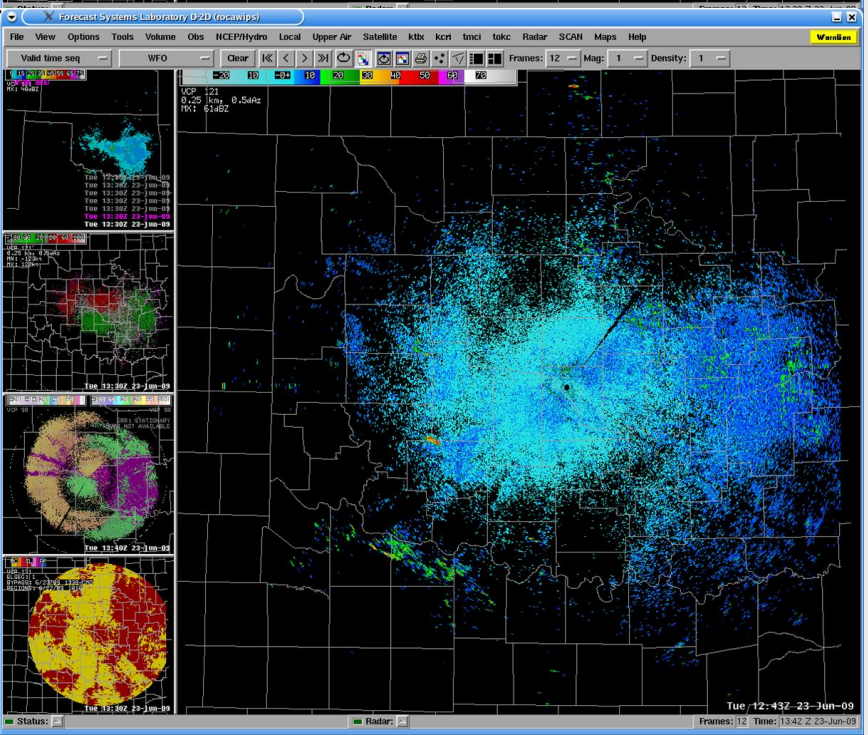


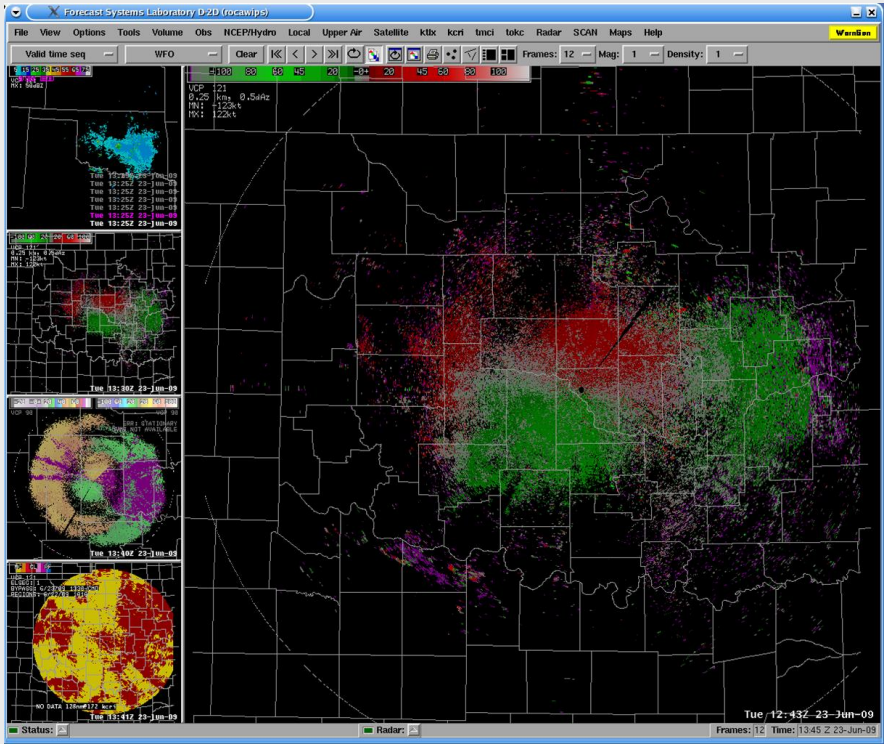



KCRI 6/23/2009
12:43Z

Widespread AP

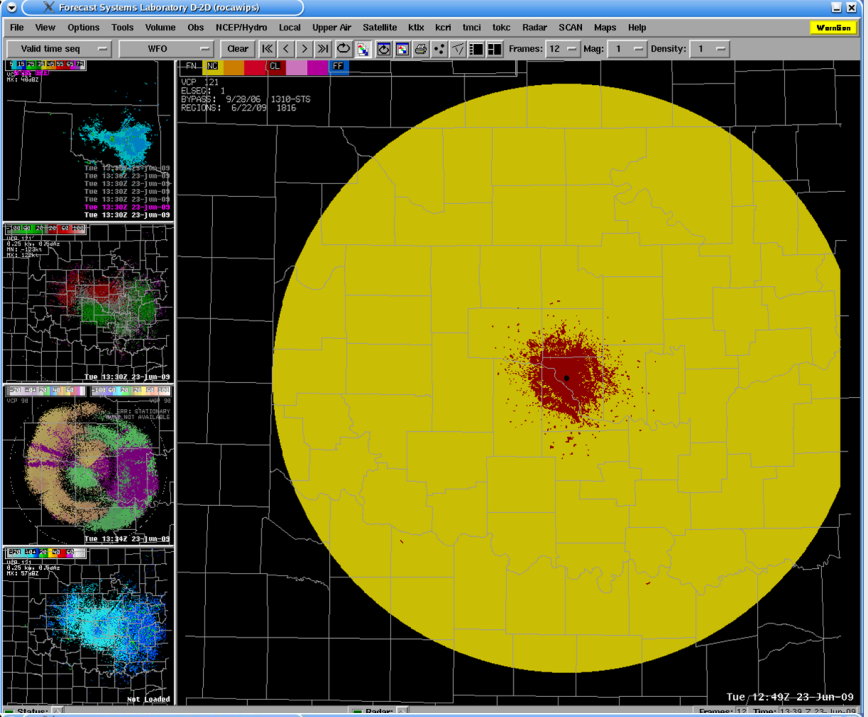


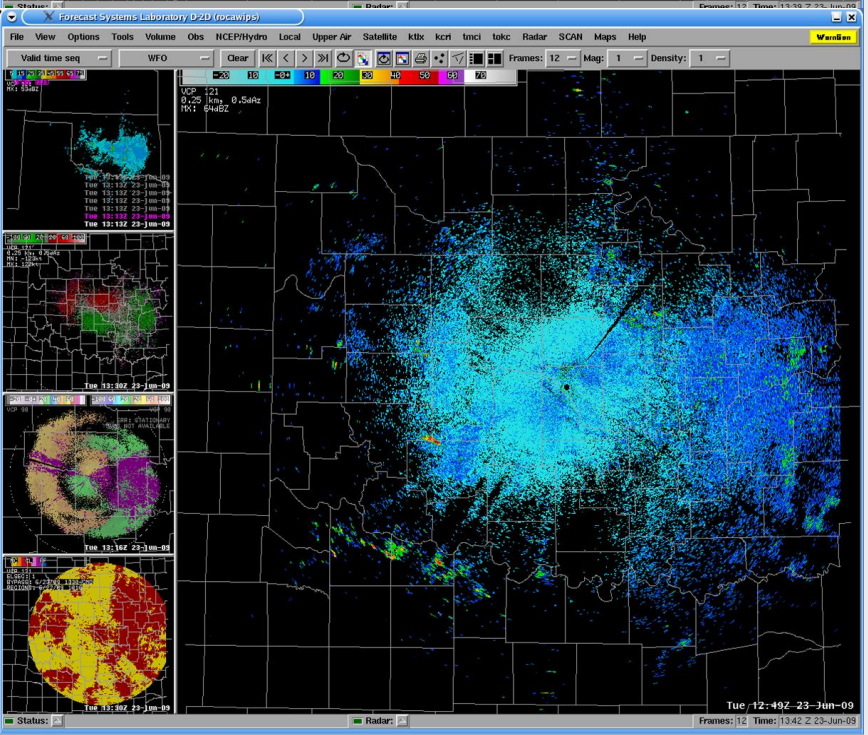



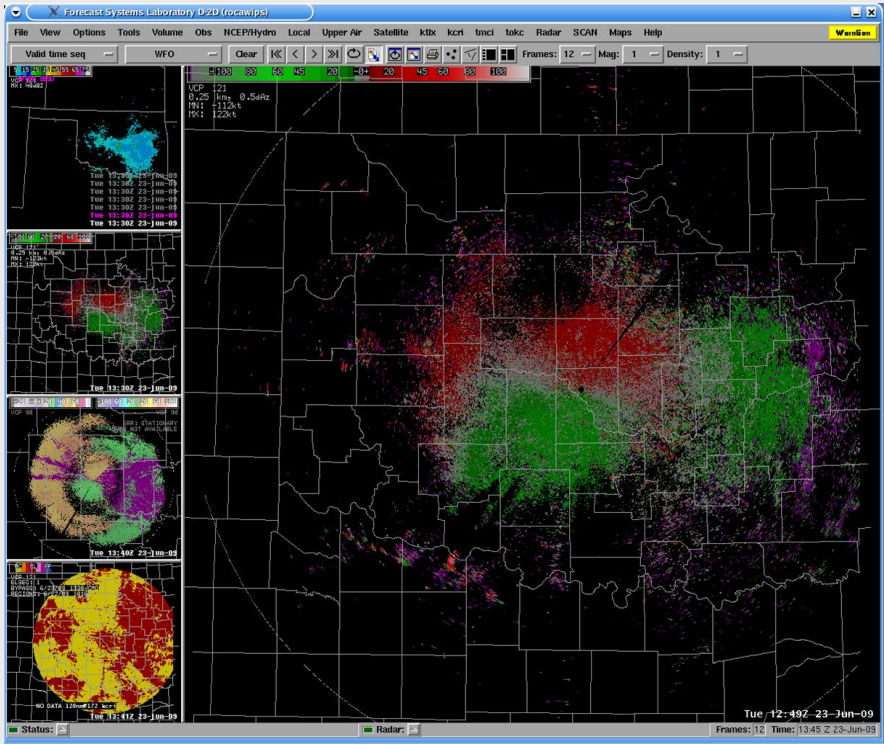



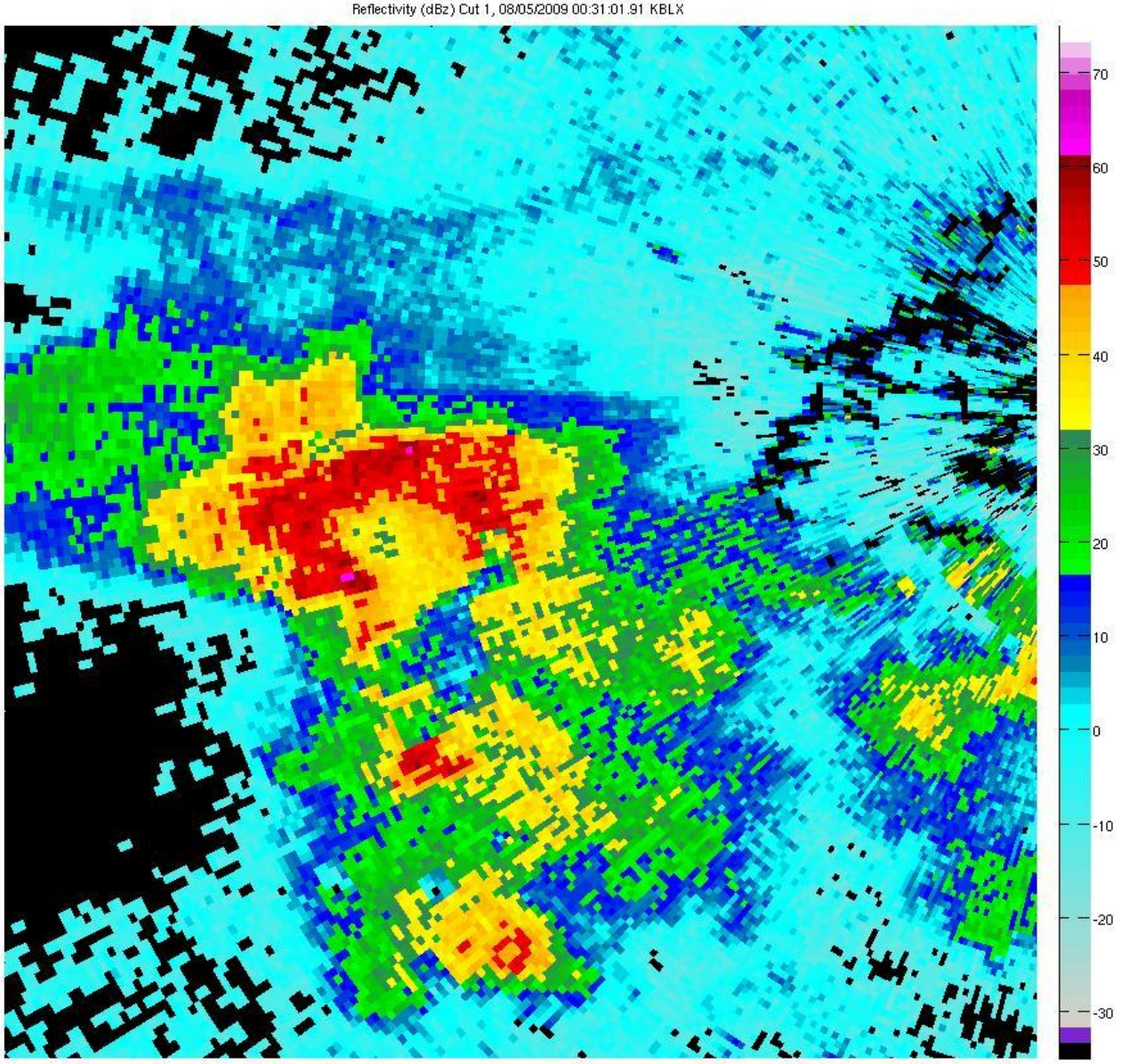
KCRI 6/23/2009
12:49Z

AP Gone?

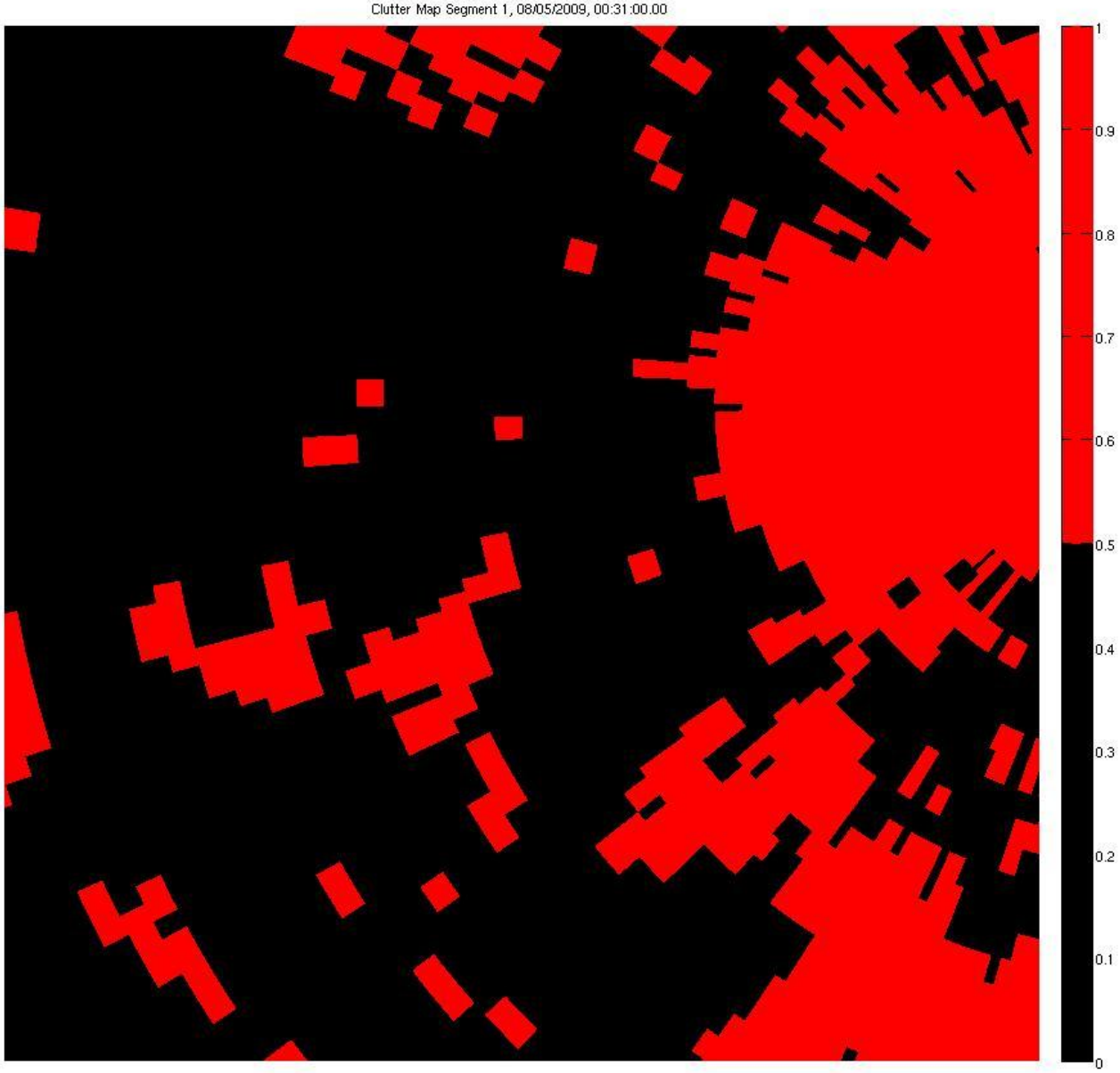


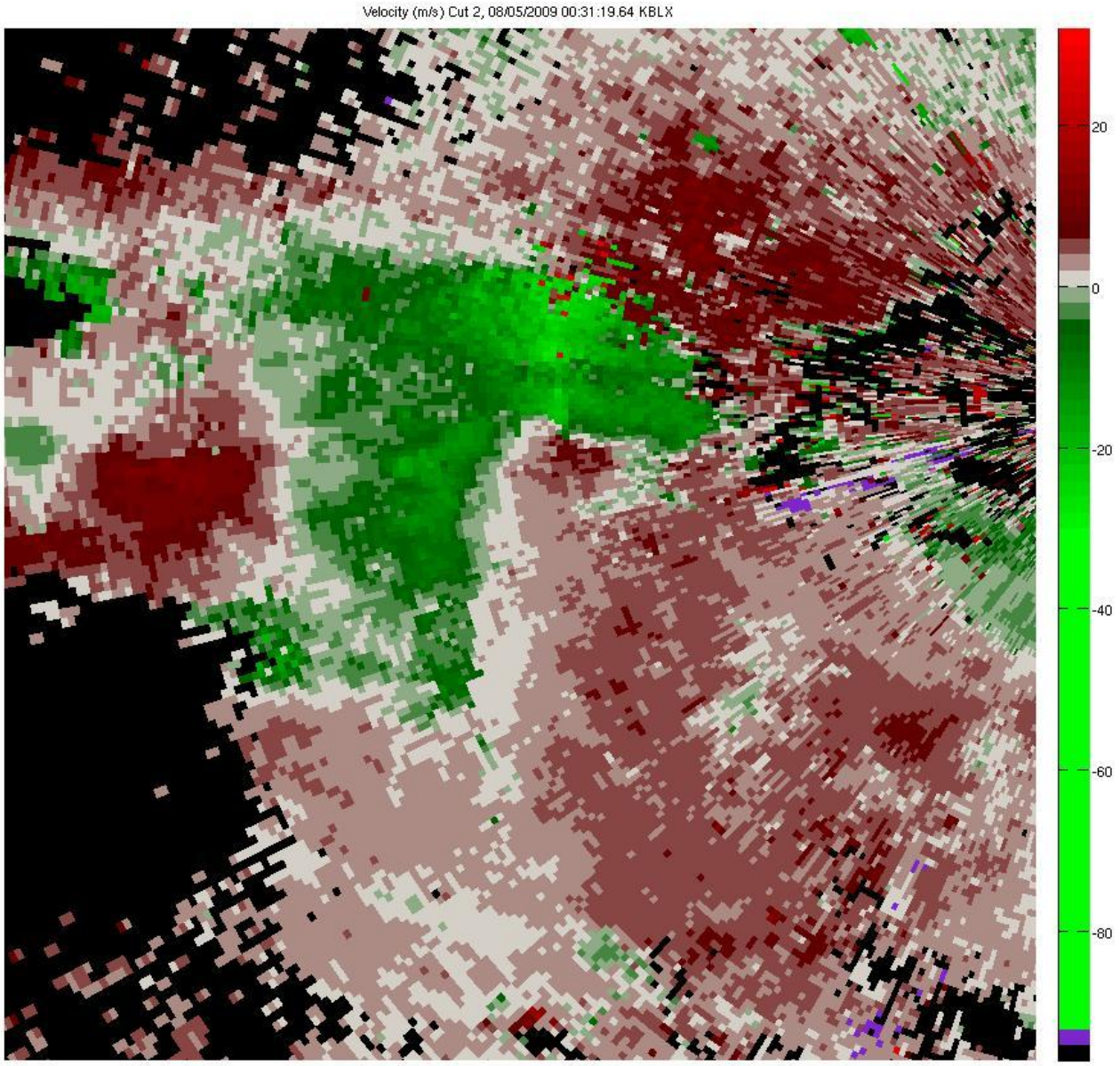





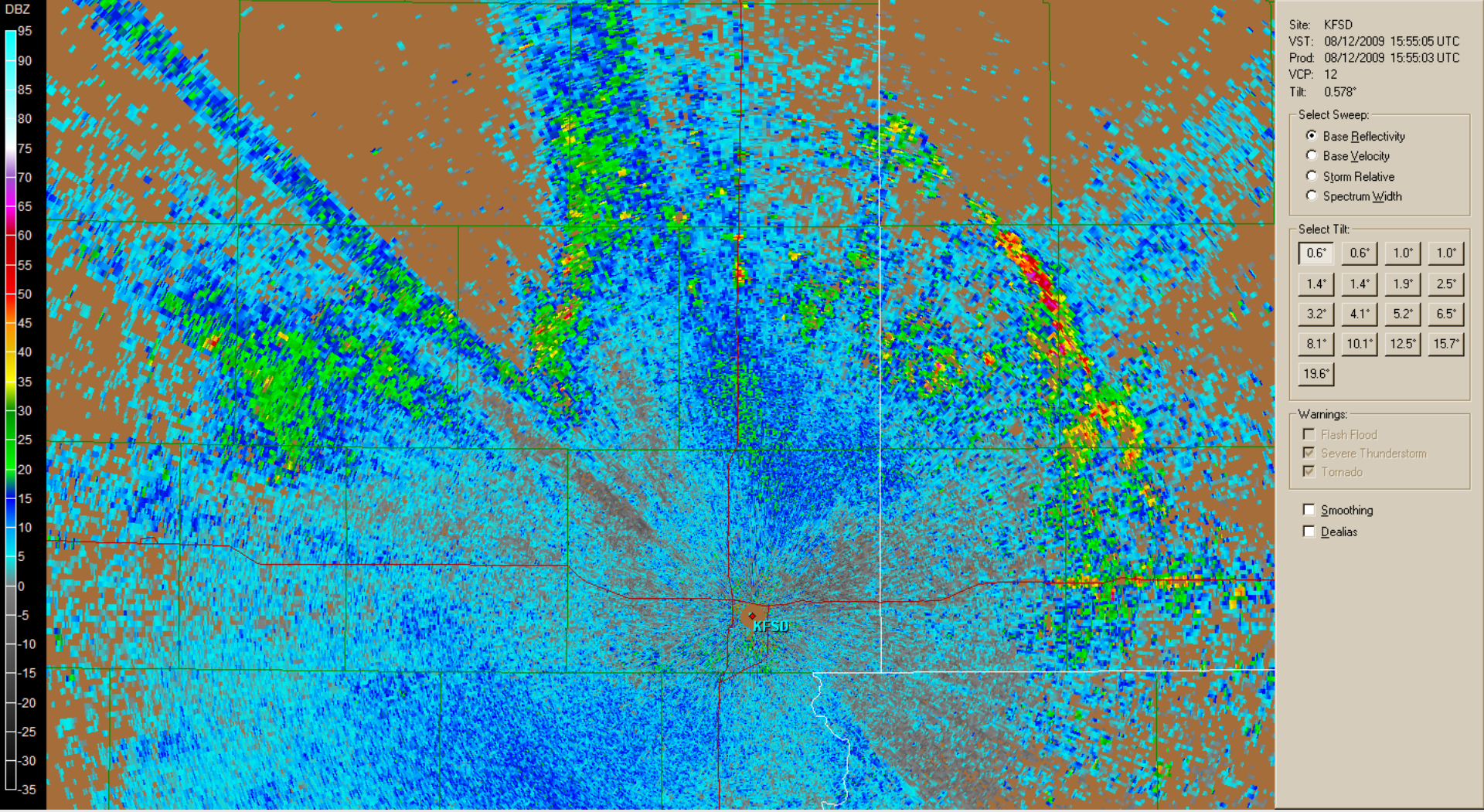

KBLX
8/5/2009
Reflectivity




KBLX
8/5/2009
CMD Map

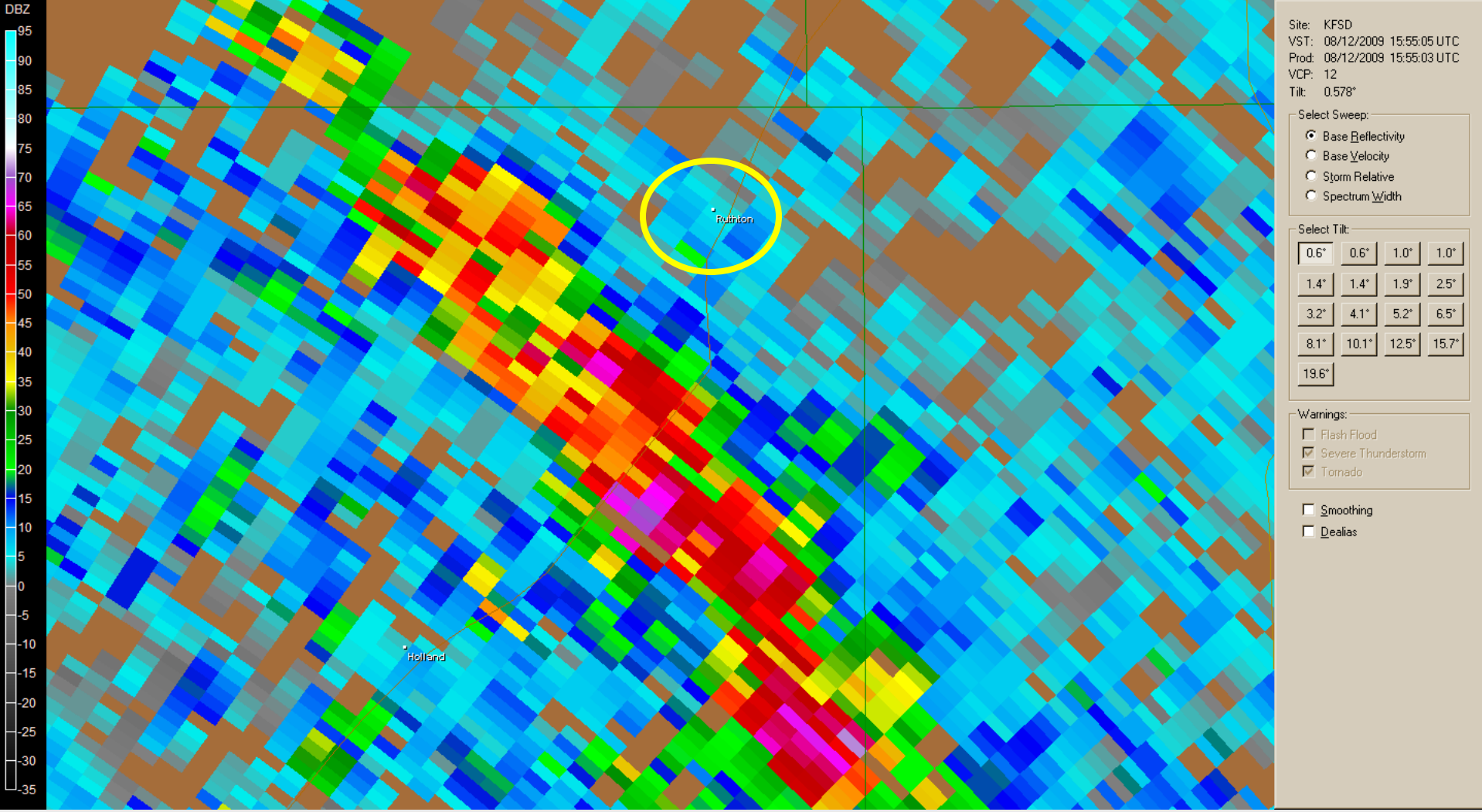



KBLX
8/5/2009
Velocity




KFSD Sioux Falls SD August 12, 2009

Reflectivity 155505Z

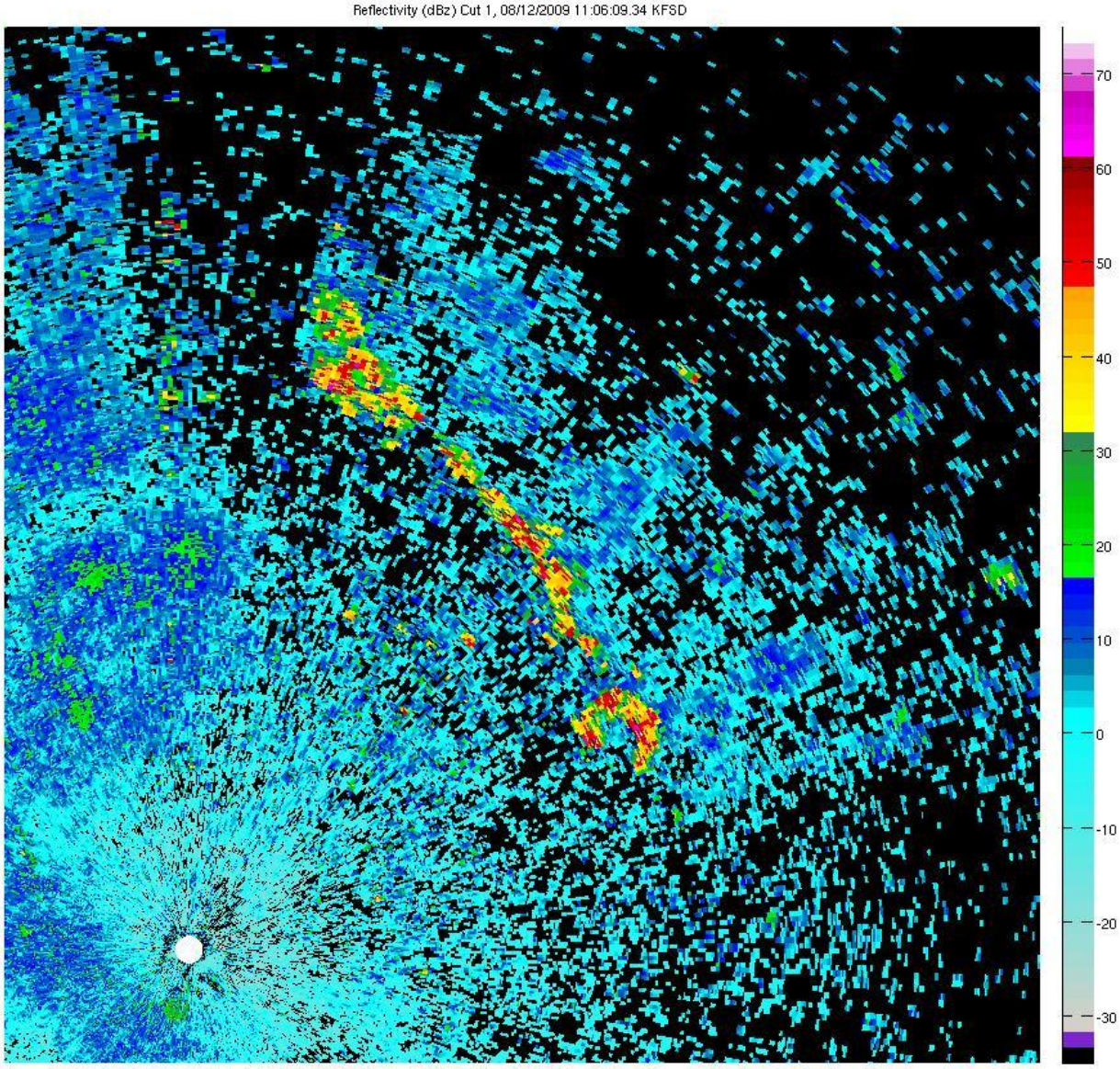


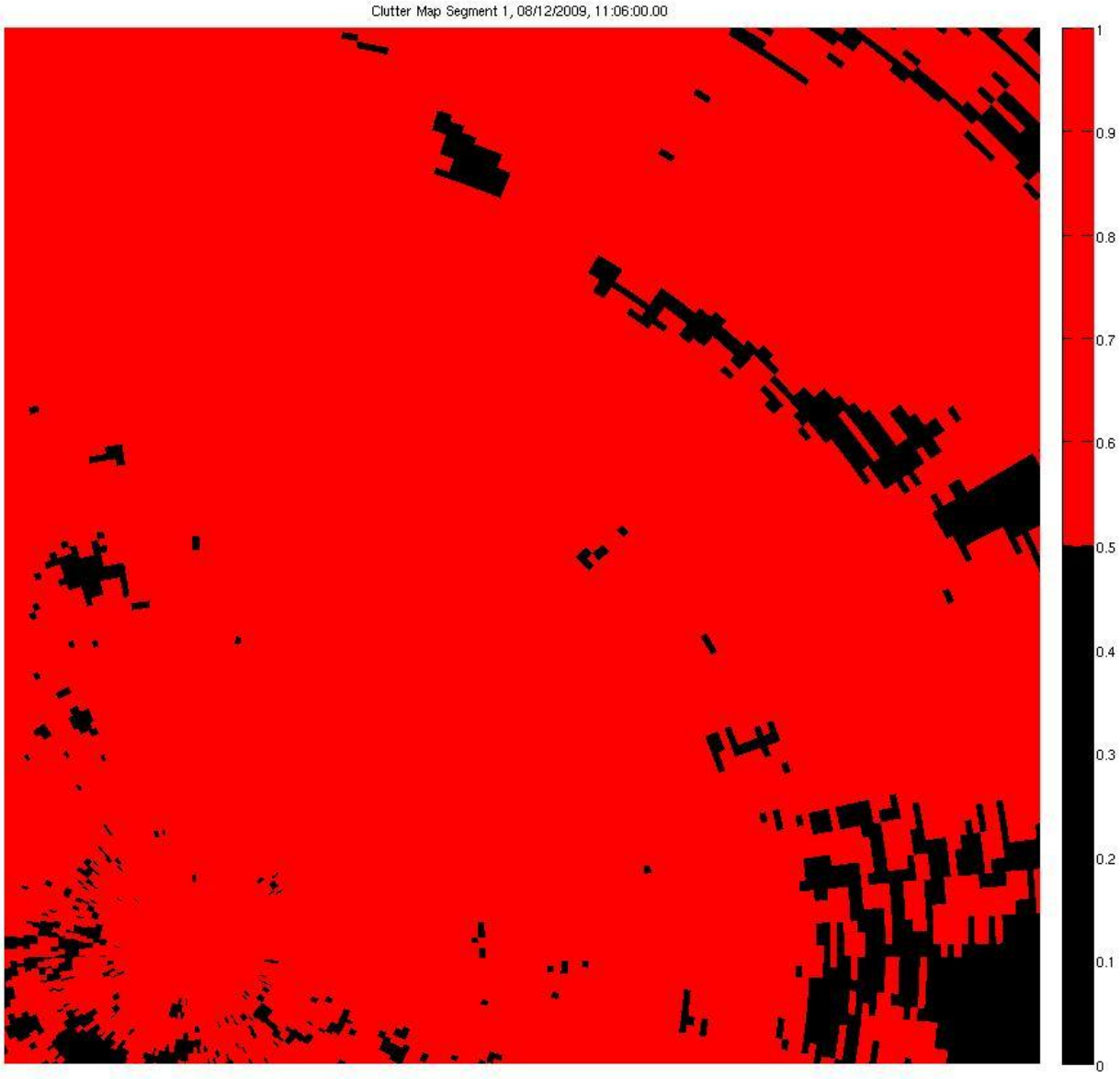

Reflectivity 155505Z

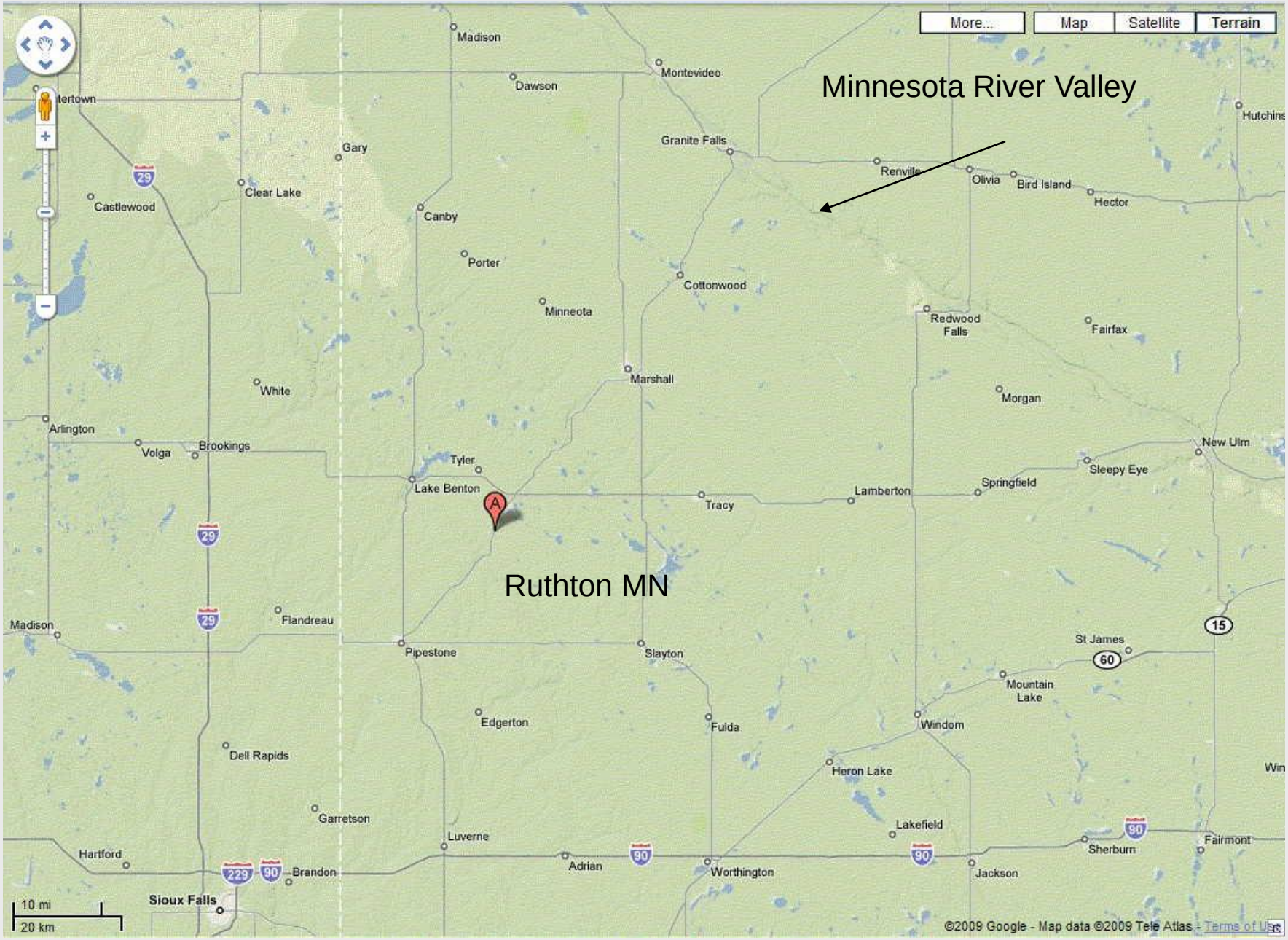
Google maps Address

Wind Turbines!  Did CMD detect?

Ruthton, Minnesota


Reflectivity (dBz) Cut 1, 08/12/2009 11:06:09.34 KFSD
70
60
50
40
30
20
10
0
-10
-20
-30


Clutter Map Segment 1, 08/12/2009, 11:06:00.00
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0


More...
Map
Satellite
Terrain
Minnesota River Valley
Ruthton MN
Madison
Montevideo
Dawson
Granite Falls
Renville
Olivia
Bird Island
Hector
Hutchins
Gary
Clear Lake
Castlewood
Canby
Porter
Cottonwood
Minneota
Redwood Falls
Fairfax
Marshall
White
Morgan
Arlington
Volga
Brookings
Tyler
Lake Benton
Tracy
Lamberton
Springfield
Sleepy Eye
New Ulm
Flandreau
Pipestone
Slayton
St James
Mountain Lake
Edgerton
Fulda
Windom
Dell Rapids
Heron Lake
Garretson
Luverne
Lakefield
Hartford
Brandon
Adrian
Worthington
Jackson
Sherburn
Fairmont
Sioux Falls
10 mi
20 km
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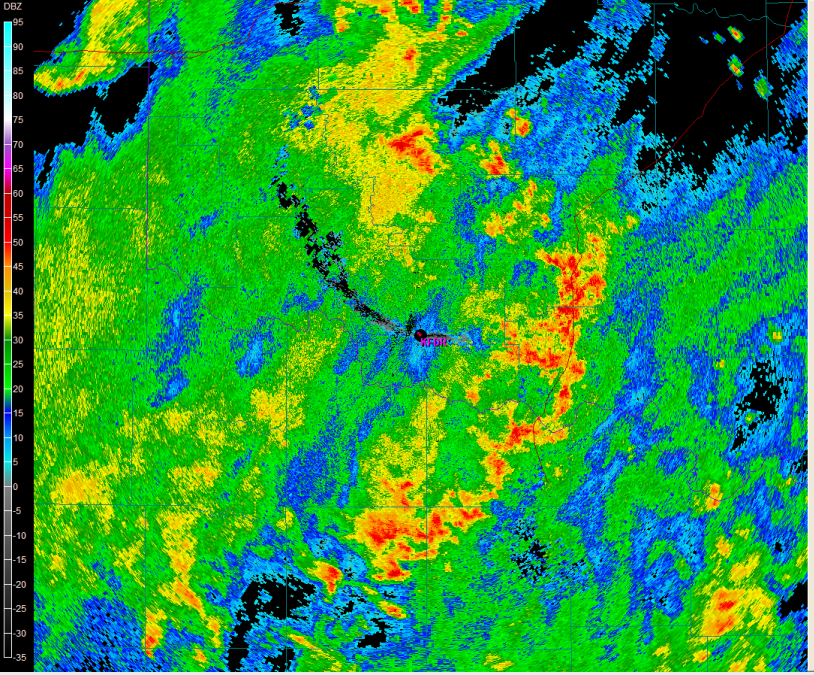
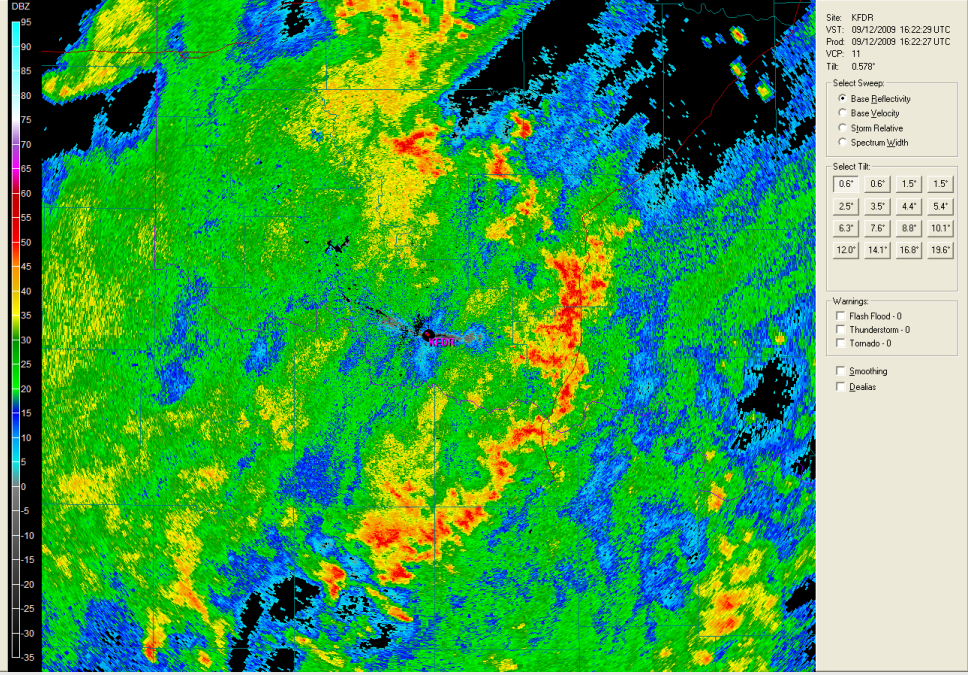
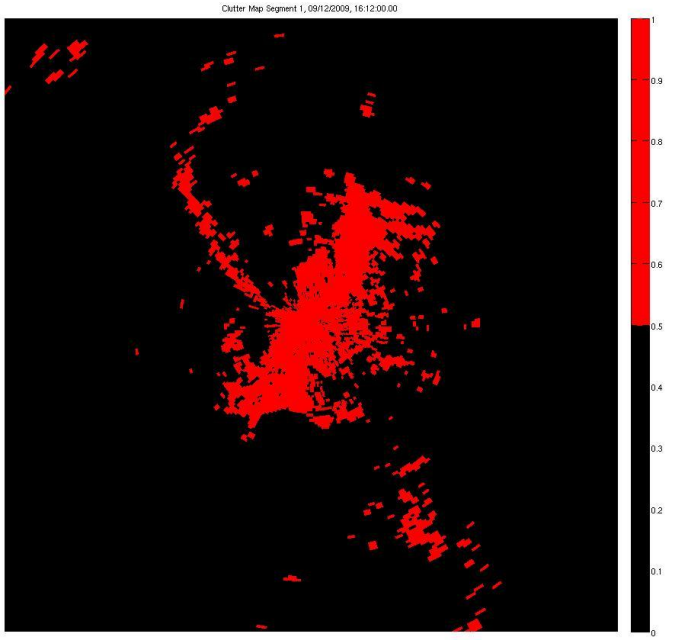
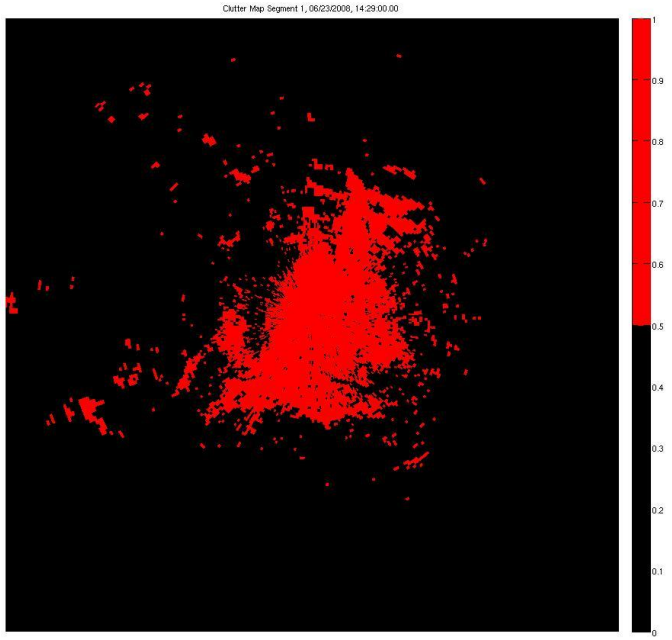


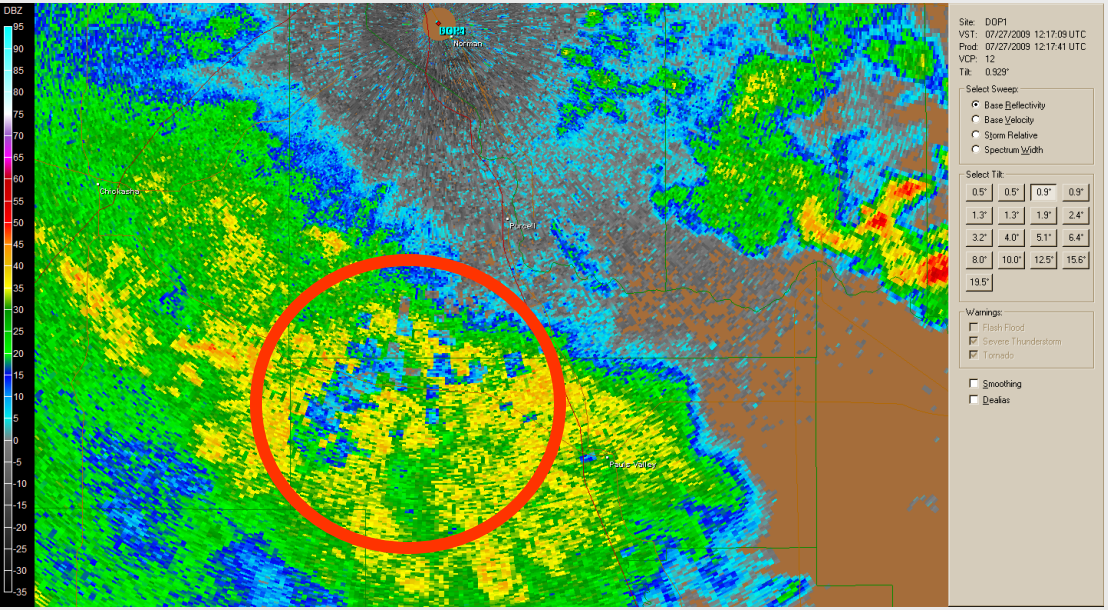




CMD KFDR 9/12/2009 False Detections Static Bypass Map

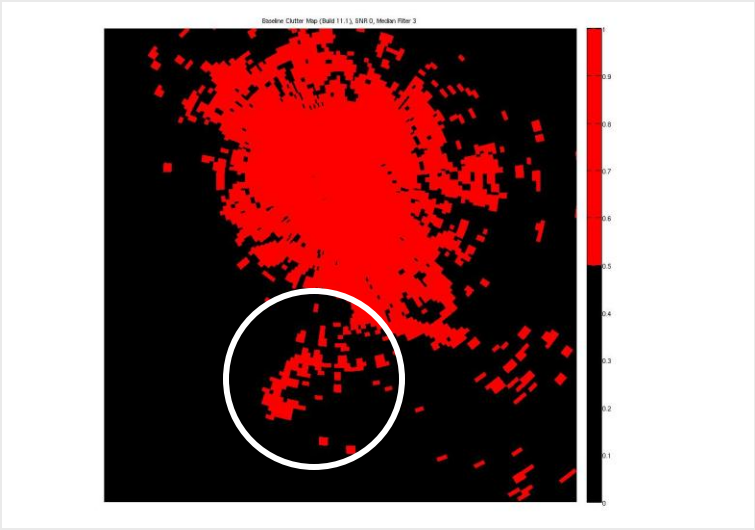


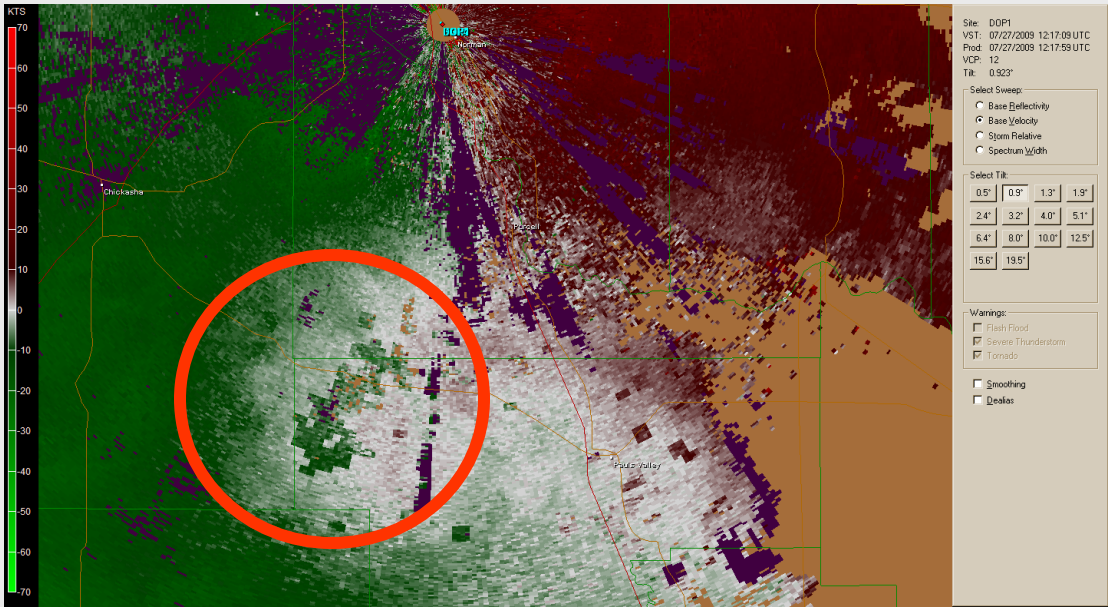



# Engineering Investigated Parameter Changes to Reduce False Alarms

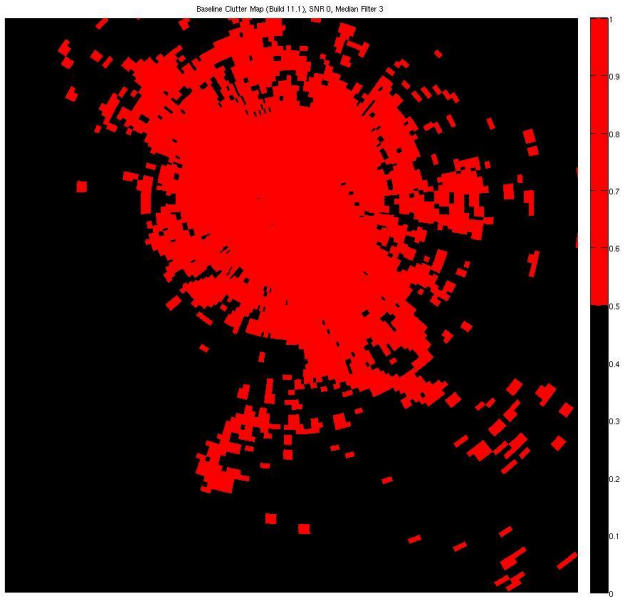



KCRI 7/27/2009

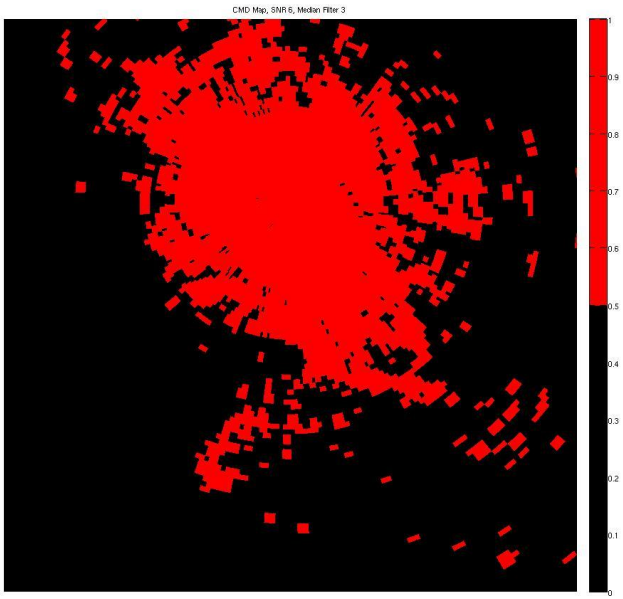




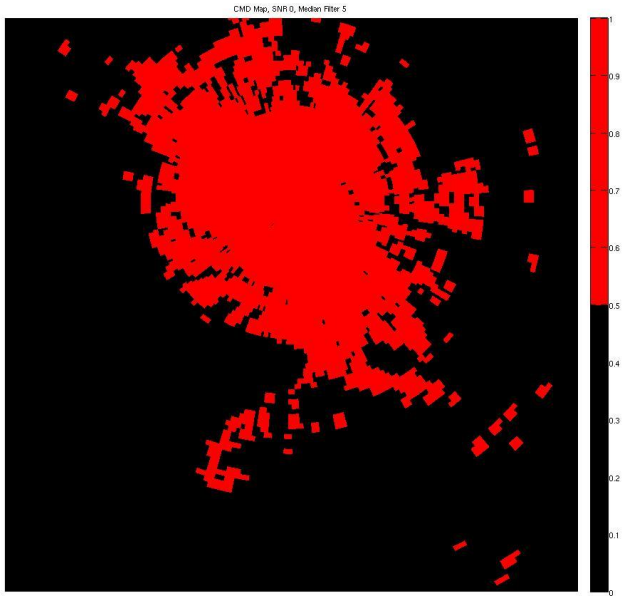
## SNR 0 MF 3 Gates



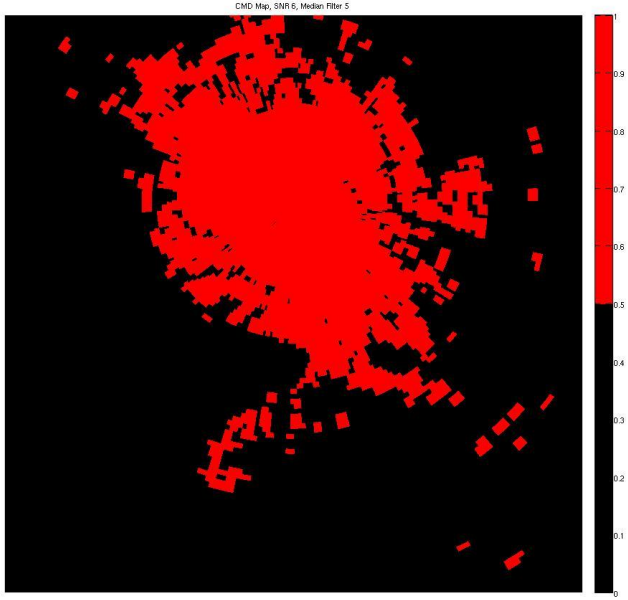

## SNR 6 MF 3 Gates




## SNR 0 MF 5 Gates




## SNR 6 MF 5 Gates

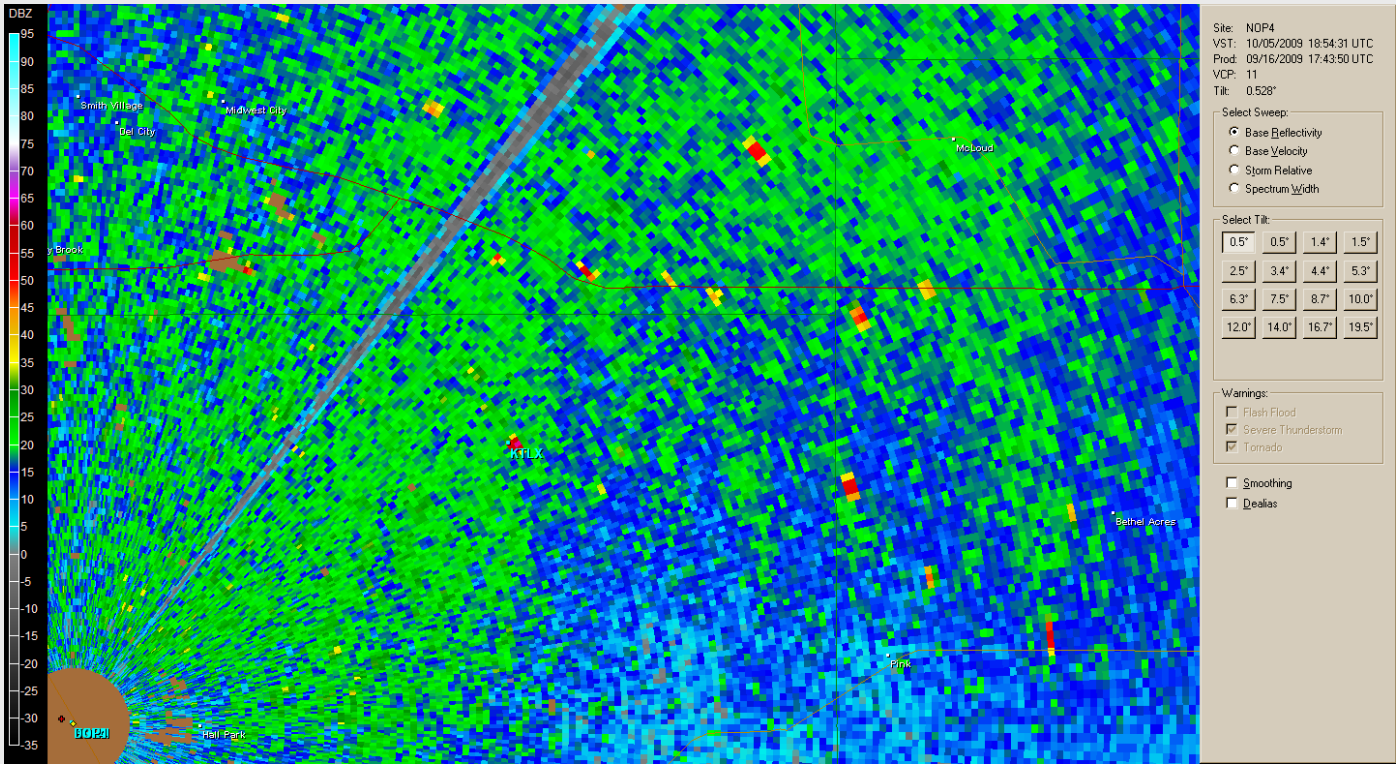


# Conclusions From Engineering Tests

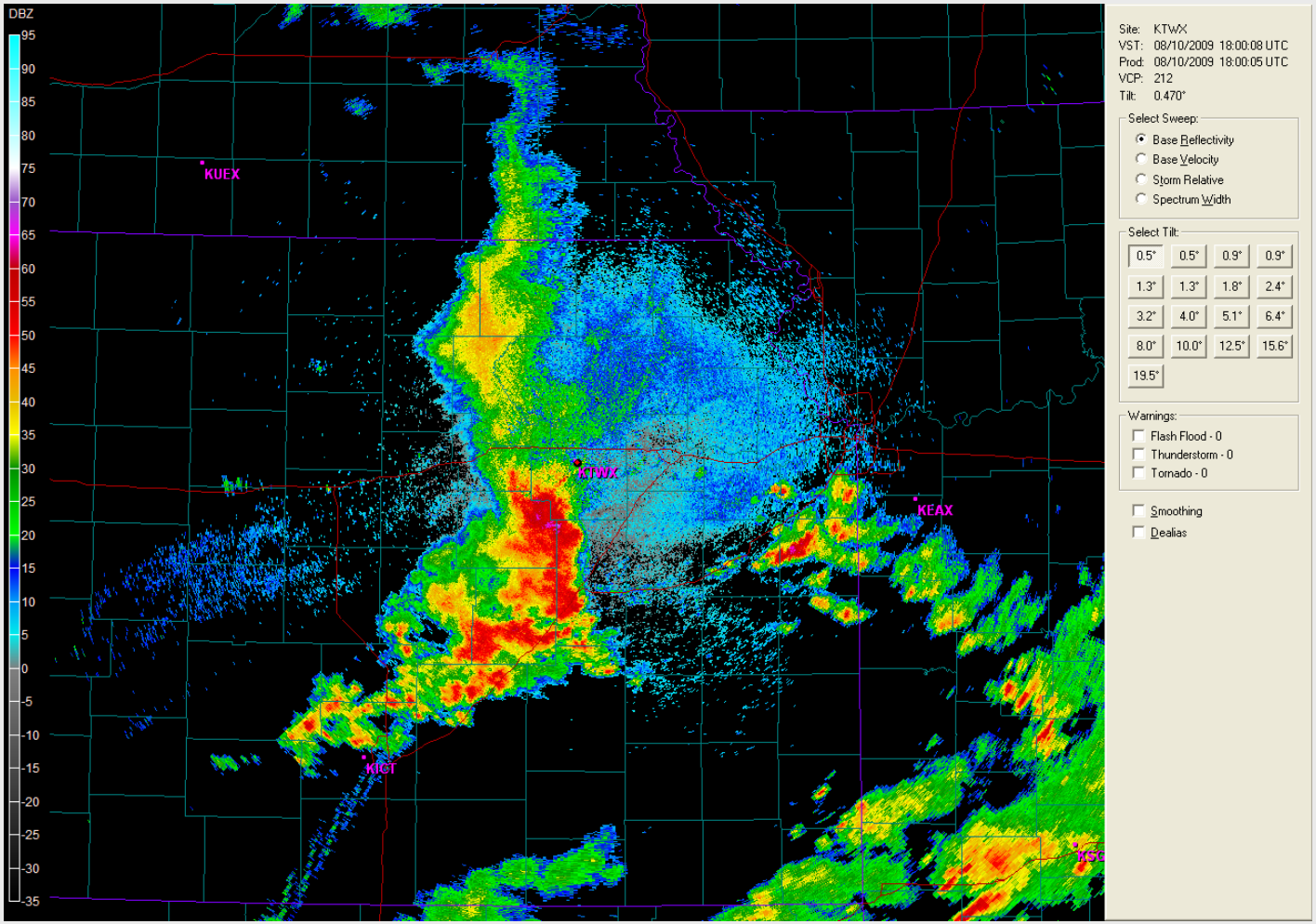
- Can reduce false detections slightly with longer Median Filter
- Results in Missed Detections
- Increasing SNR merely reduces number of bins CMD runs on
- Current parameters are optimal

9/16/2009 KCRI

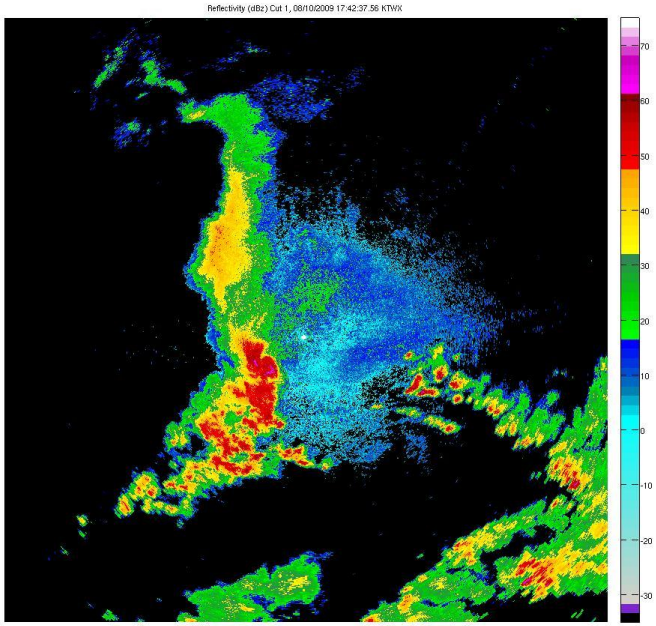
SNR 6 MF 5 Gates



# An Interesting Case:  Topeka Kansas

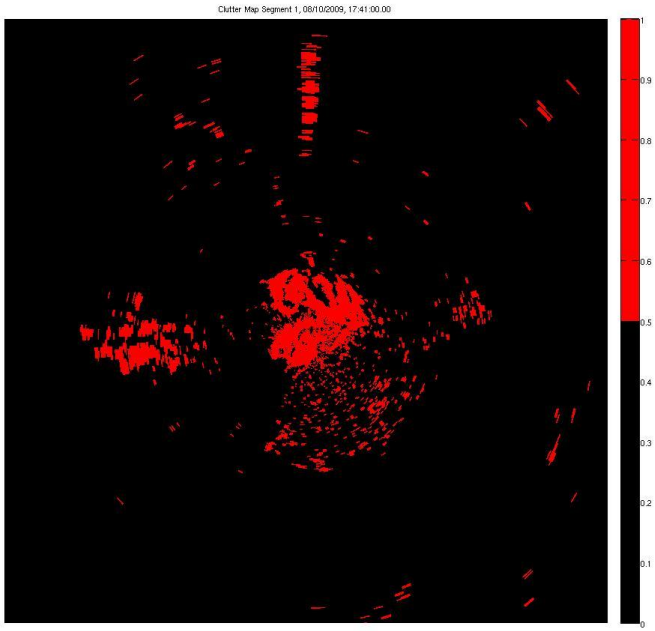


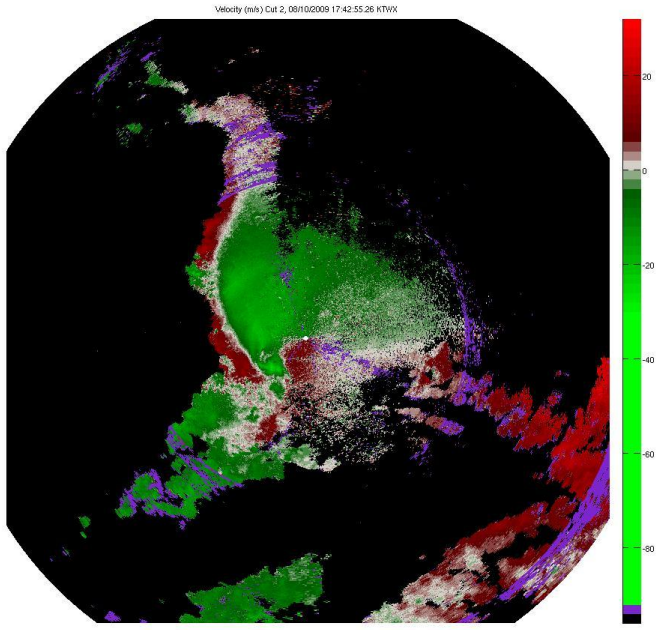

August 10, 2009

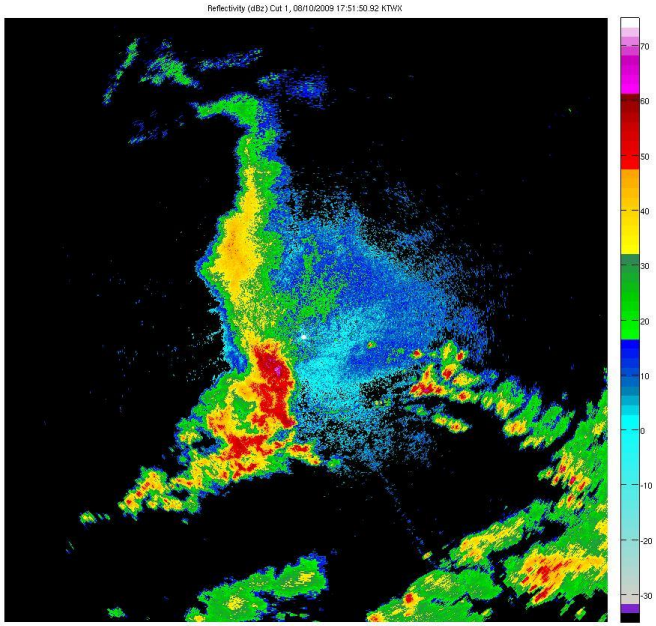



# Topeka KS 8/10/2009
# AP Event Developing

17:42:37

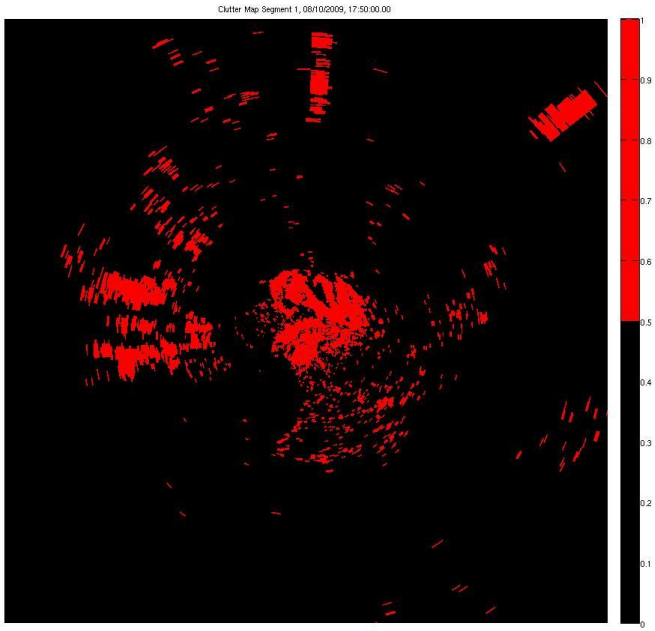


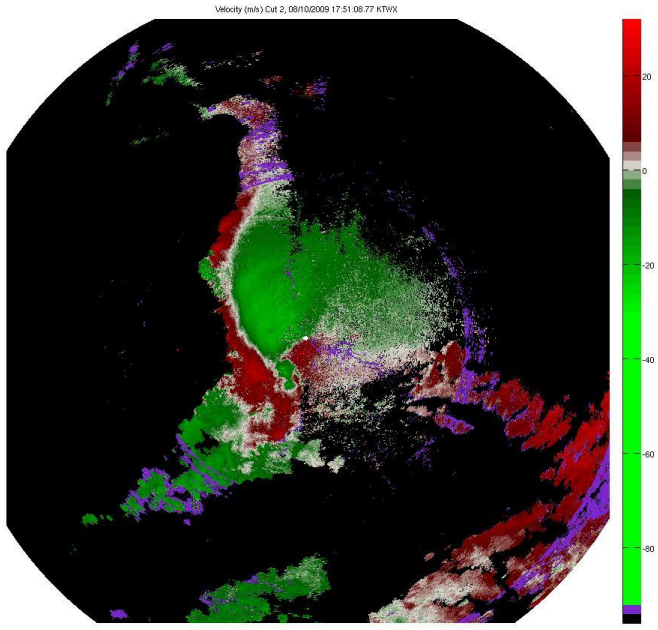



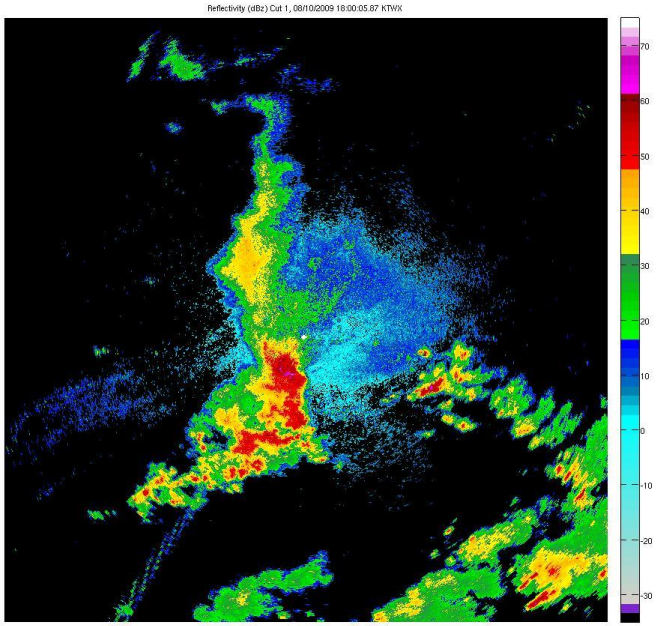



# Topeka KS 8/10/2009
# AP Event Developing

17:51:50

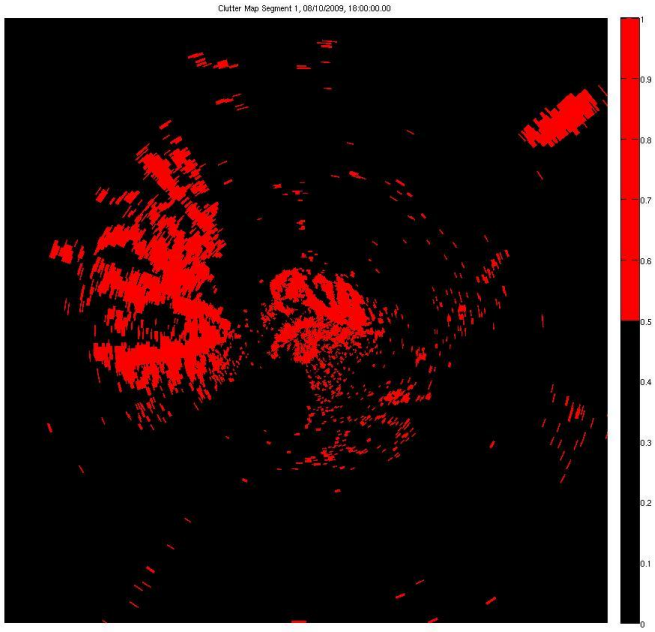


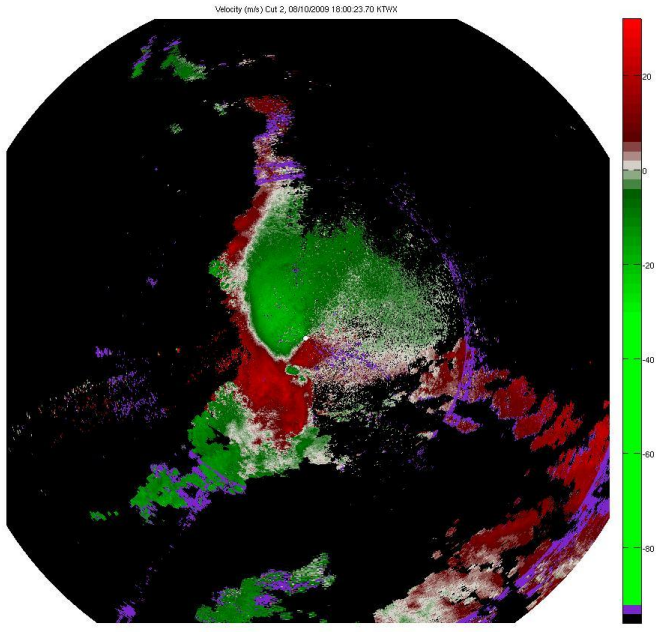



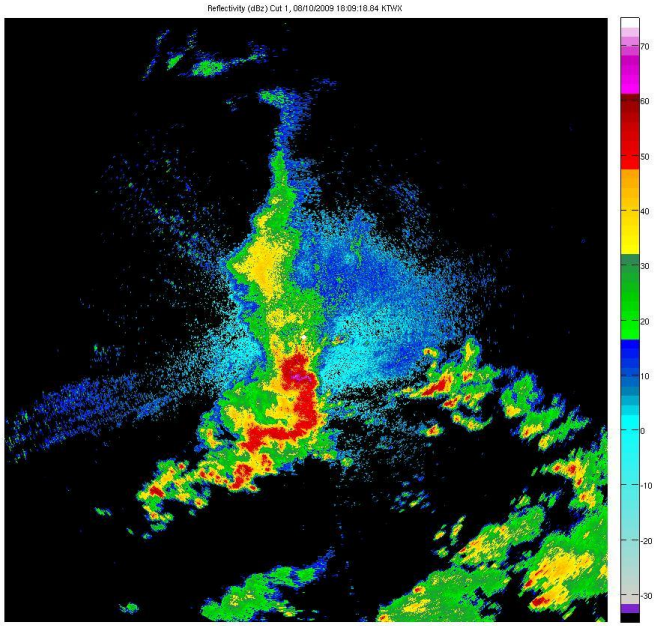



Topeka KS 8/10/2009
AP Event Developing

18:00:05

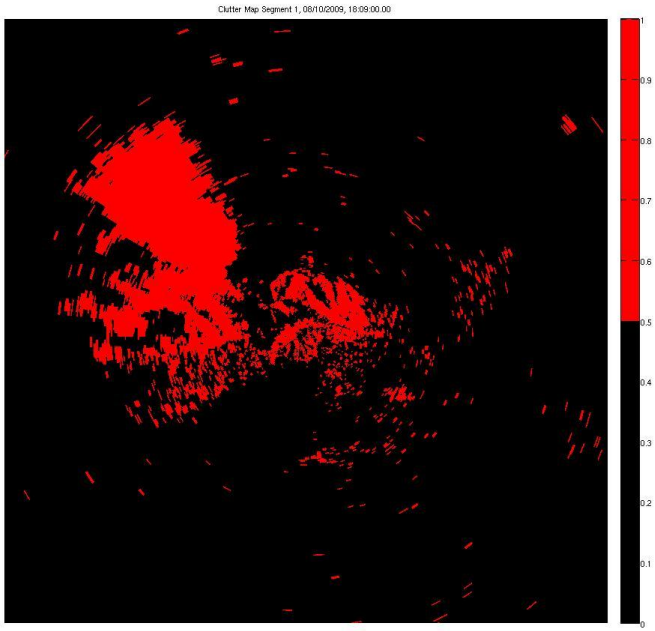


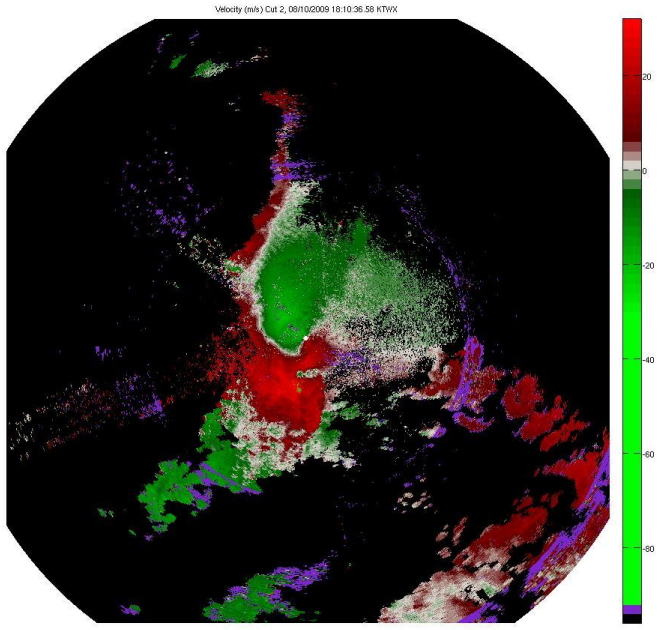



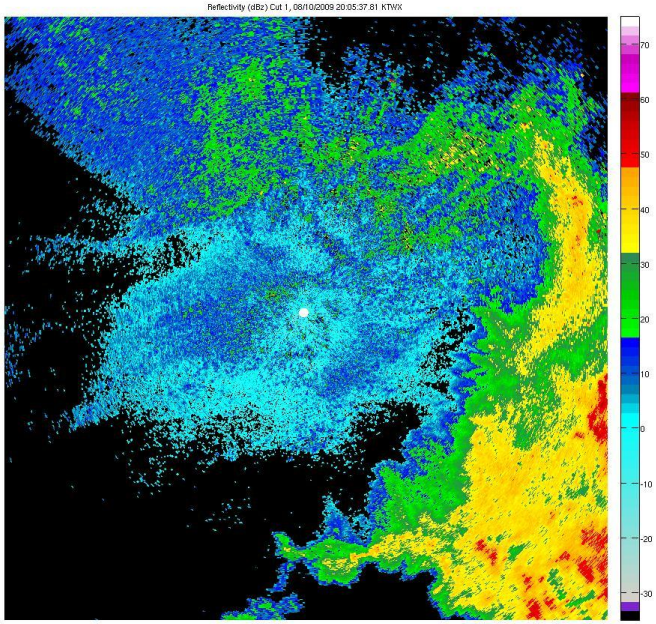



Topeka KS 8/10/2009
AP Event Developing

18:09:18

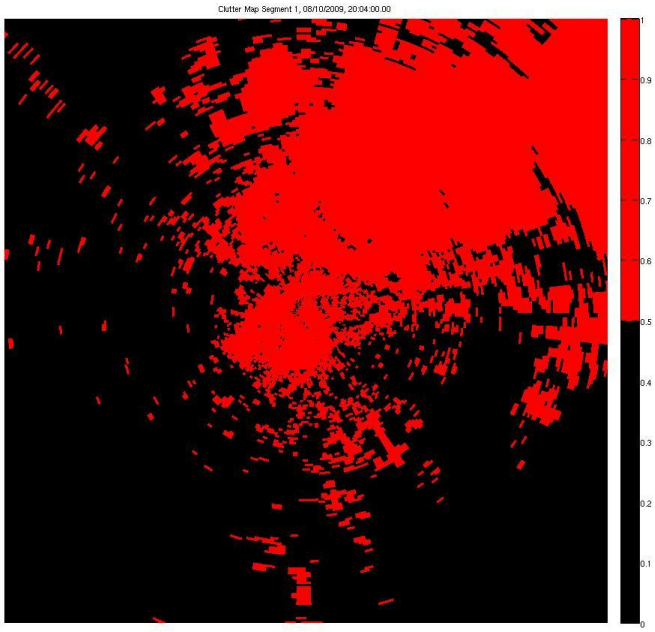


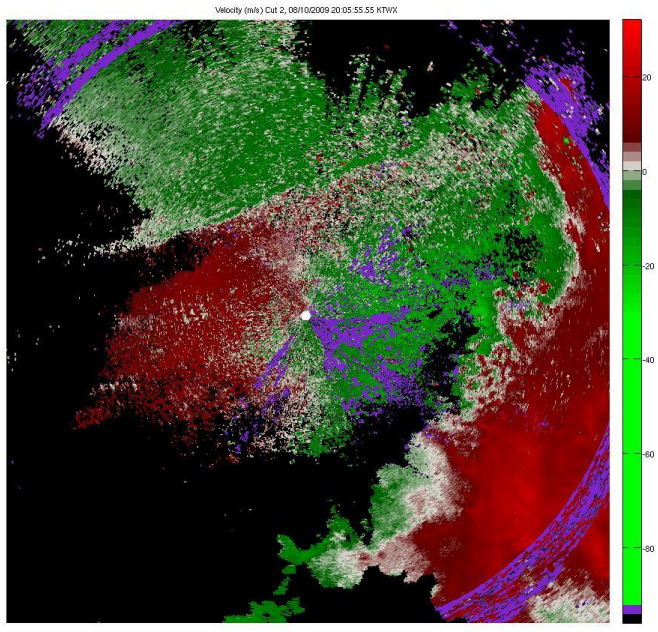



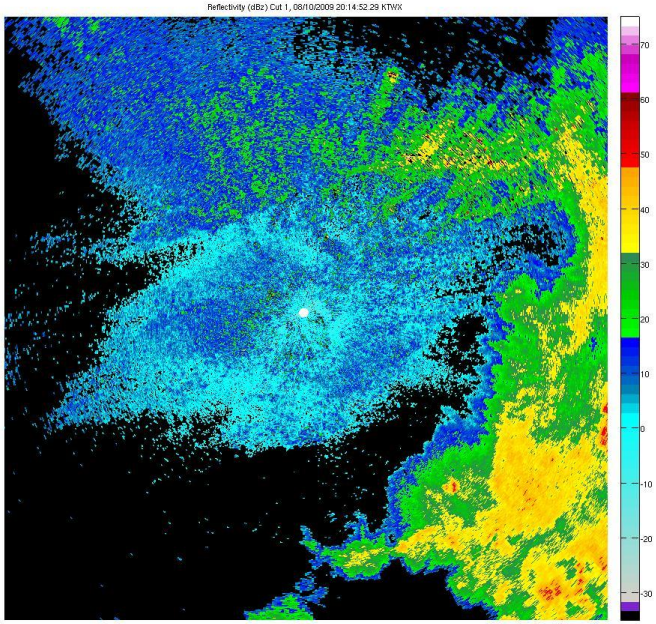



Topeka KS 8/10/2009
Frontal Passage Near Radar
Later in the Event

20:05:37

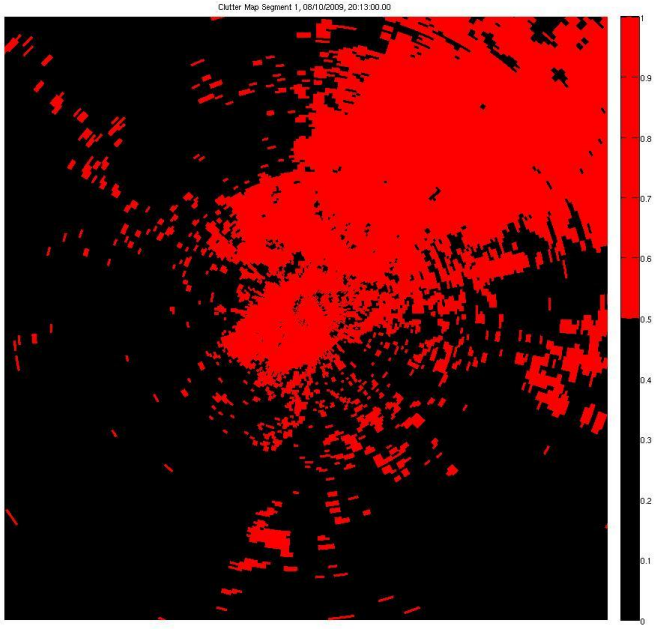


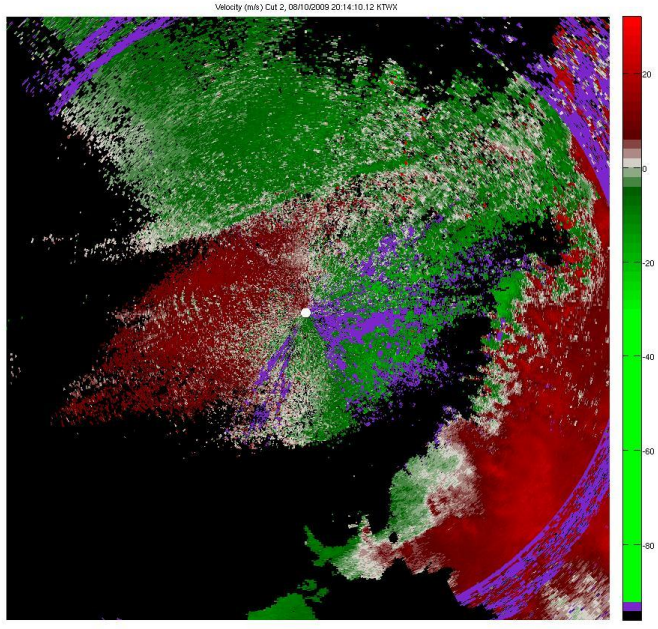



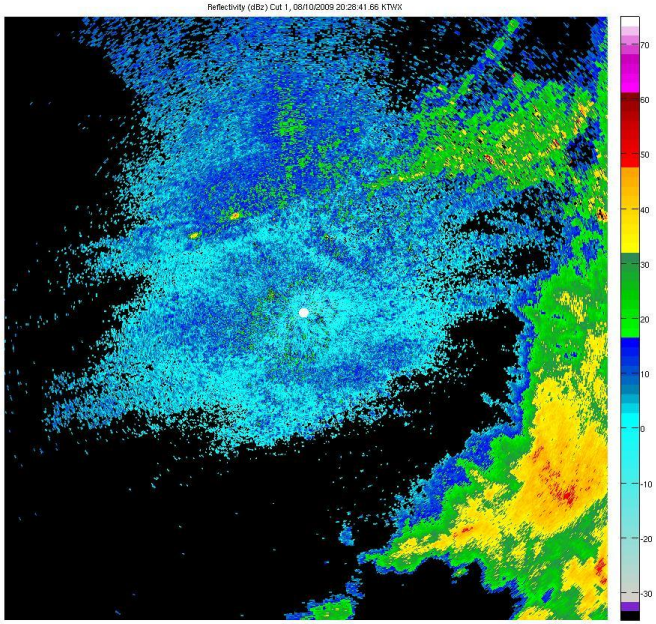



Topeka KS 8/10/2009
Frontal Passage Near Radar
Later in the Event

20:14:52

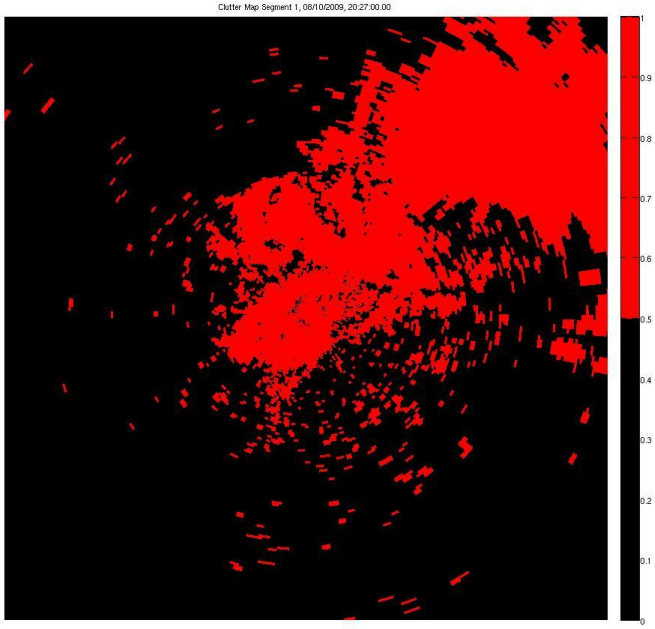


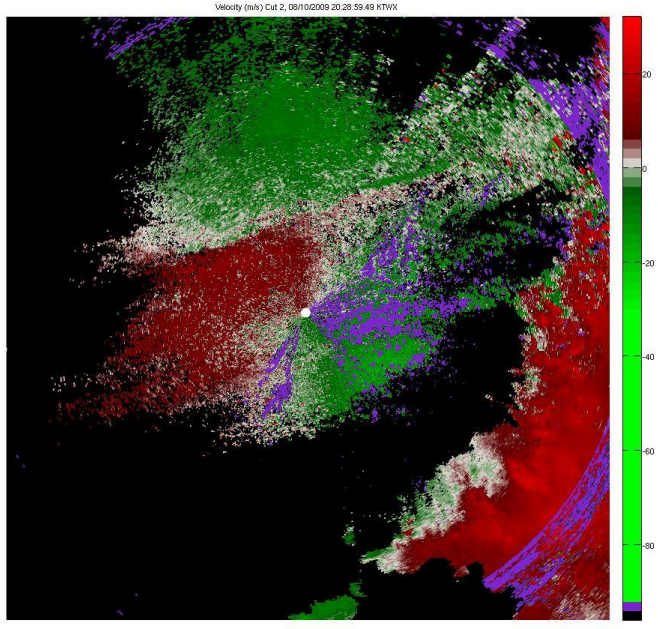






Topeka KS 8/10/2009
Frontal Passage Near Radar
Later in the Event

20:28:41



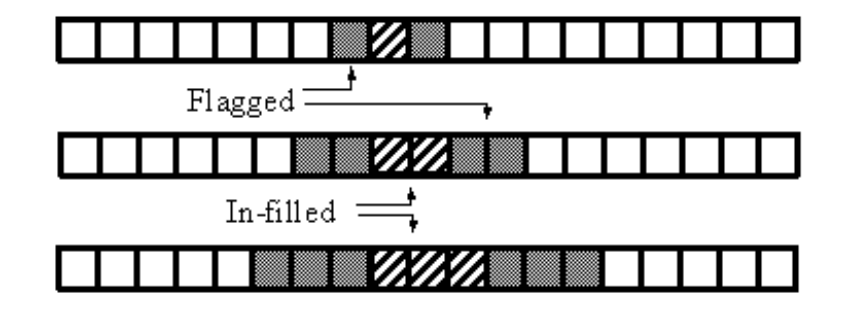
# Wrap-Up

- CMD Working well, but could be improved
- Improve CPA Computation for phase varying clutter targets (NCAR)
- Improve In-Fill Filter (NCAR)
- Add Polarimetric Variables (have algorithm description)
- Clutter Filter Performance Improvements:
  - Adaptive windowing
  - Narrow expected clutter spectrum width (GMAP seed value)
  - Reduce aggressiveness of clutter residue censoring
- Look at alternative filtering methods

# Future Work:
# NCAR's Improved CPA Calculation

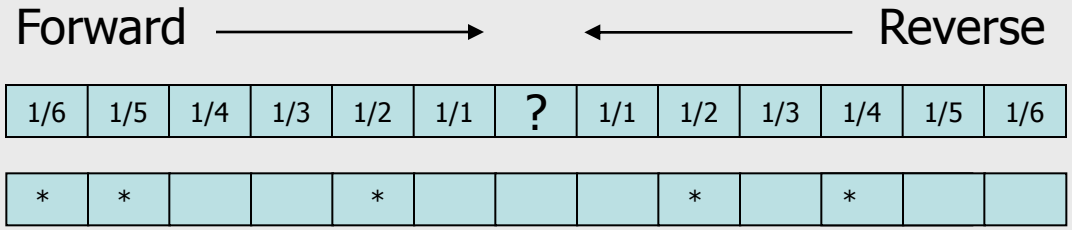
- Divide the time series into 8 parts.
- Compute the CPA factors for each part.
- Compute CPA using some fraction of the parts which yield a maximum value.
- The leads to higher values of CPA and a generally smoother result.
- The membership function for CPA must be adjusted to account for the higher values.

# The existing CMD flag in-fill filter




- The filter 'fills in' gates for which the flag is not set, if there are flagged gates on either side.
- The filter is designed to fill in gaps of the type shown above.
- Specifically, it will fill in the gaps of the following type:
  - 1 un-flagged gate between adjacent flagged gates
  - 2 un-flagged gates with at least 2 flagged gates on either side
  - 3 un-flagged gates with at least 3 flagged gates on either side

# Proposed new CMD flag in-fill filter




- One each side of the gate in question, construct a computational kernel with weights decreasing with distance from the gate.
- In the forward direction, sum up the weights for gates which have the flag set (e.g. marked * = 1/2 + 1/5 + 1/6 = 0.76)
- In the reverse direction, sum up the weights for gates which have the flag set (e.g. marked * = ½ + ¼ = 0.75)
- IF forward_weight >= 0.7 AND reverse_weight >= 0.7 THEN
  set CMD_flag at center gate to TRUE
- IF not, set CMD_flag at center gate to FALSE

# NCAR's Improved In-Fill Filter