Dual-Polarization (DP) Evaluation

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Overview

- Summary since last TAC
- Issues Resolved
- Improved Capability
- Remaining Challenges

DP: Summary since last TAC

- December 2009
  - Sensitivity difference between KOUN and KCRI
    - Between 6 and 8 dB
    - Examples shown
  - Calibration differences
    - Examples shown
  - SME Panel #1: Would DP sensitivity loss affect operations?
    - Up to 4 dB sensitivity loss ok, otherwise operational assessment needed.
- January 2010
  - Contractor redesigned receiver
  - Improved dynamic range and sensitivity
- March 2010
  - SME Panel #2
    - confirmed results of first panel
    - saw great potential for use of DP in operations

DP: Summary since last TAC

- March 2010 ENG
  - 5.0 to 5.5 dB Sensitivity Difference between KOUN and KCRI
    - 1.5 dB sensitivity loss due to frequency differences
      - KOUN = 2.7 GHz KCRI =2.95 GHz
    - 3.5 - 4 dB sensitivity loss due to DP H/W http://ams.confex.com/ams/91Annual/webprogram/Manuscript/Paper183654/Sensitivity_Operational_Wx_Radars_Ice_27thIIPS_Jan2011_compact.pdf
  - The expected sensitivity loss for any given radar due to DP H/W will be 3.5 – 4 dB

DP: Summary since last TAC

- May 2010
  - Eng Signal processing assessment
  - Calibration differences resolved on KOUN and KCRI by ROC Eng and El techs
  - ZDR not fully calibrated but good base data was available to begin algorithm evaluation
- June - August 2010
  - High ZDR values resolved - example shown
  - Fingerprint artifact resolved – example shown
  - 12 DP precipitation algorithm cases evaluated
    - Software bugs identified and fixed
    - 4 Algorithm science issues resolved, 4 issues remain
    - ZDR calibration not accurate enough for QPE use

DP: Summary since last TAC

- August 2010
  - Operational Assessment –will be briefed later
- May 2010 – December 2010
  - Improved capability
    - DP variables and algorithms – examples shown
  - Continued visual and statistical evaluation
  - ZDR calibration was too high before December 2010 and too low after

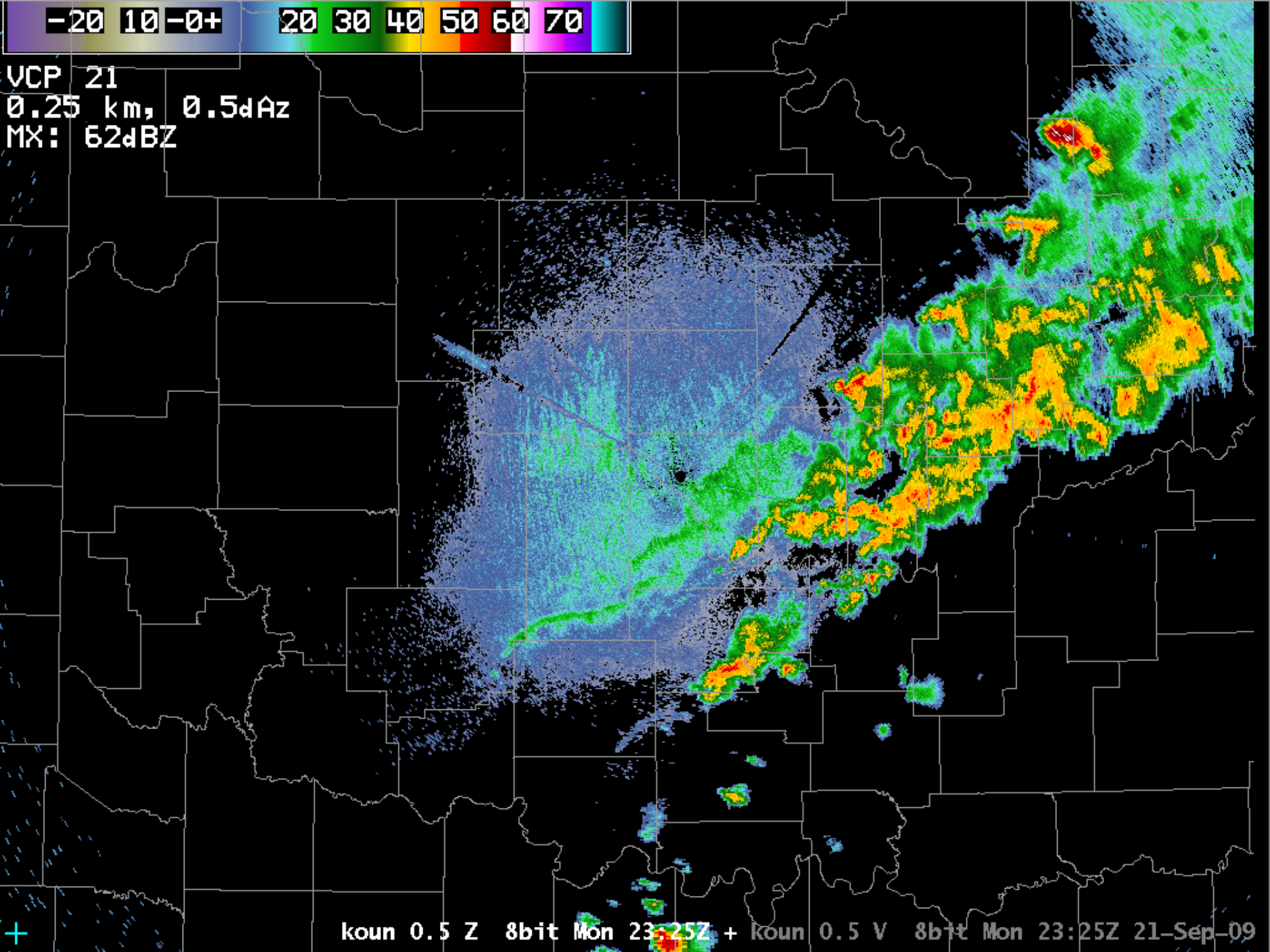
DP: Summary since last TAC

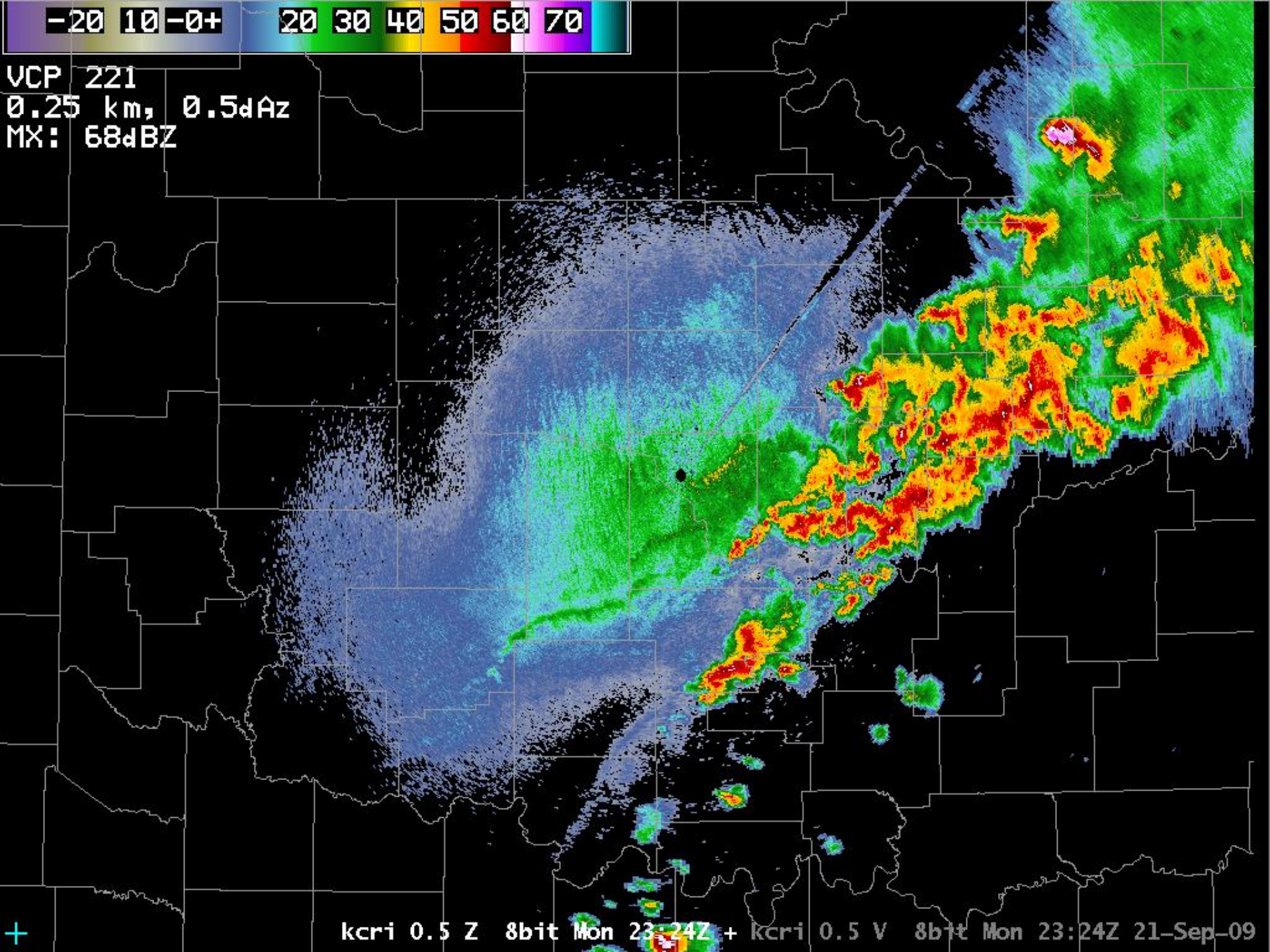
- January 2011
  - Hardware and software fixes to KOUN
- January – February 2011
  - Current Status
    - 4 algorithm science issues to be investigated and tested
    - ZDR calibration stable but 0.5 dB too low
      - Subjective human ZDR evaluation – examples shown
      - ZDR useful for forecaster visual interpretation but not good enough for DP QPE algorithm use

Issues Resolved

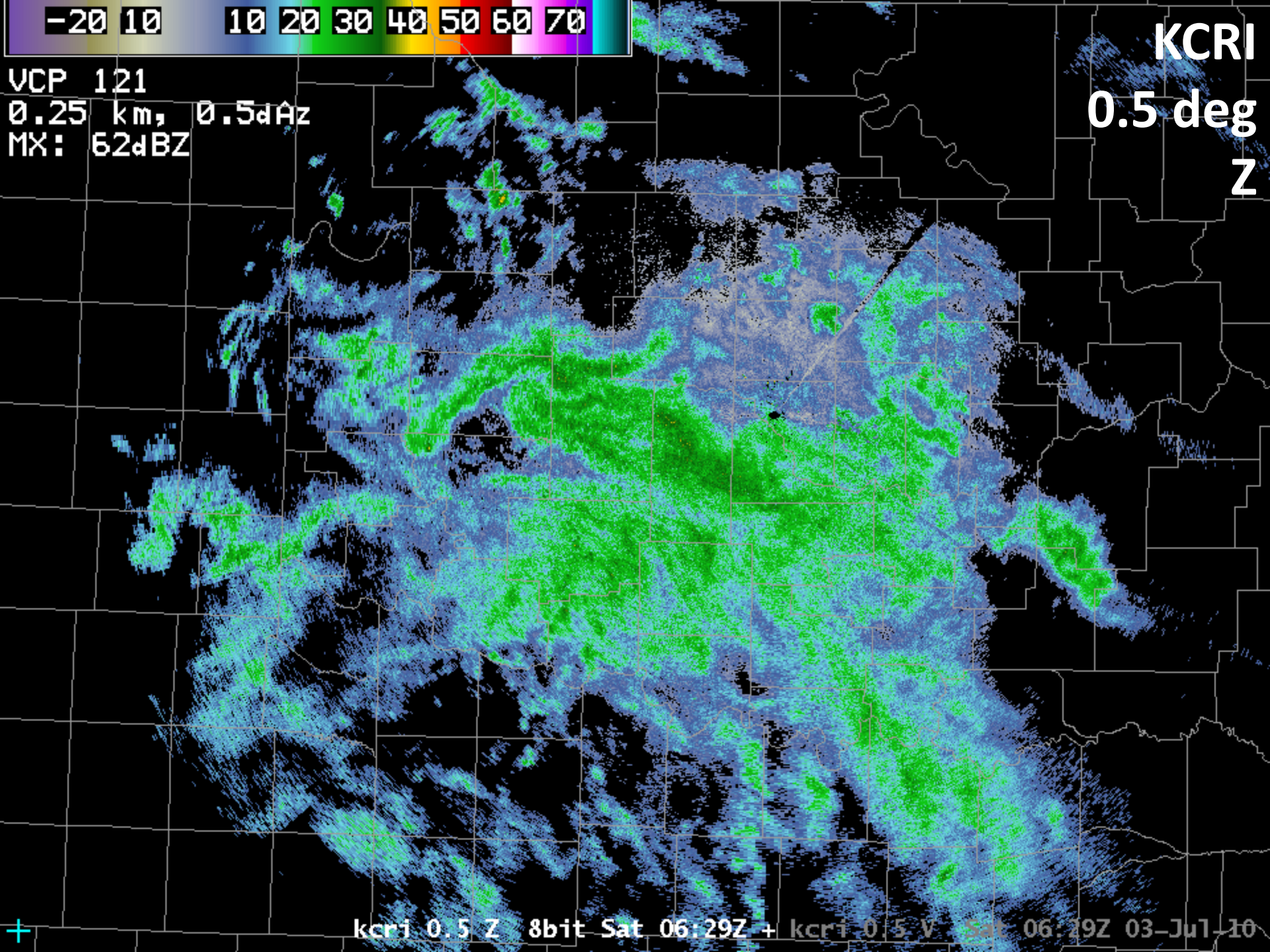
Initially, Sensitivity/Calibration Not Good

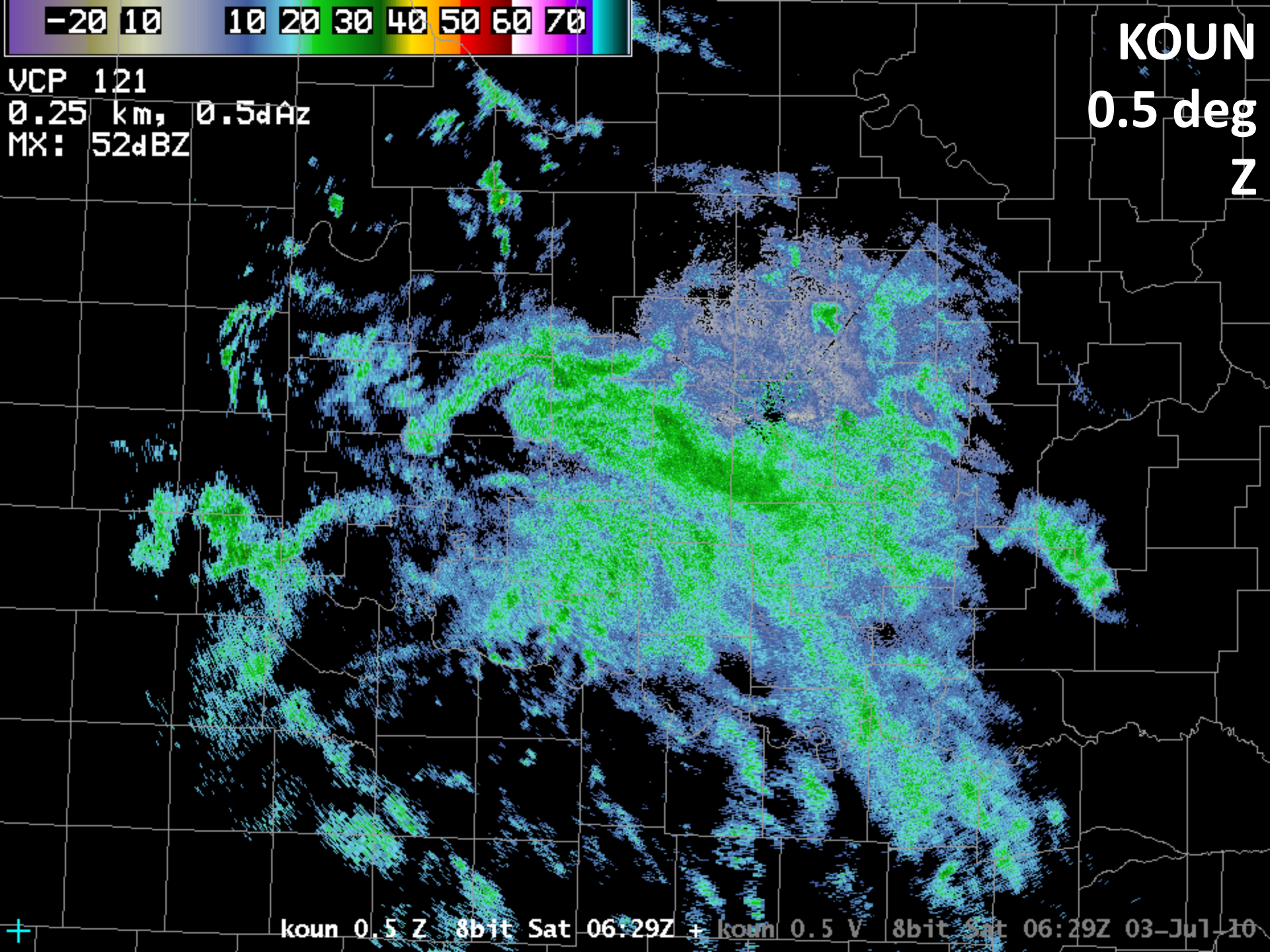
- Initial KOUN / KCRI sensitivity and calibration issues
- 2325 UTC Sep. 22, 2009
- KOUN: VCP 21
- KCRI: VCP 221
- Heavy precip SE, clear air bloom, strong cold front
- ROC El techs fixed calibration issues on KOUN and KCRI
- ROC ENG eventually sorted out the sensitivity issue.

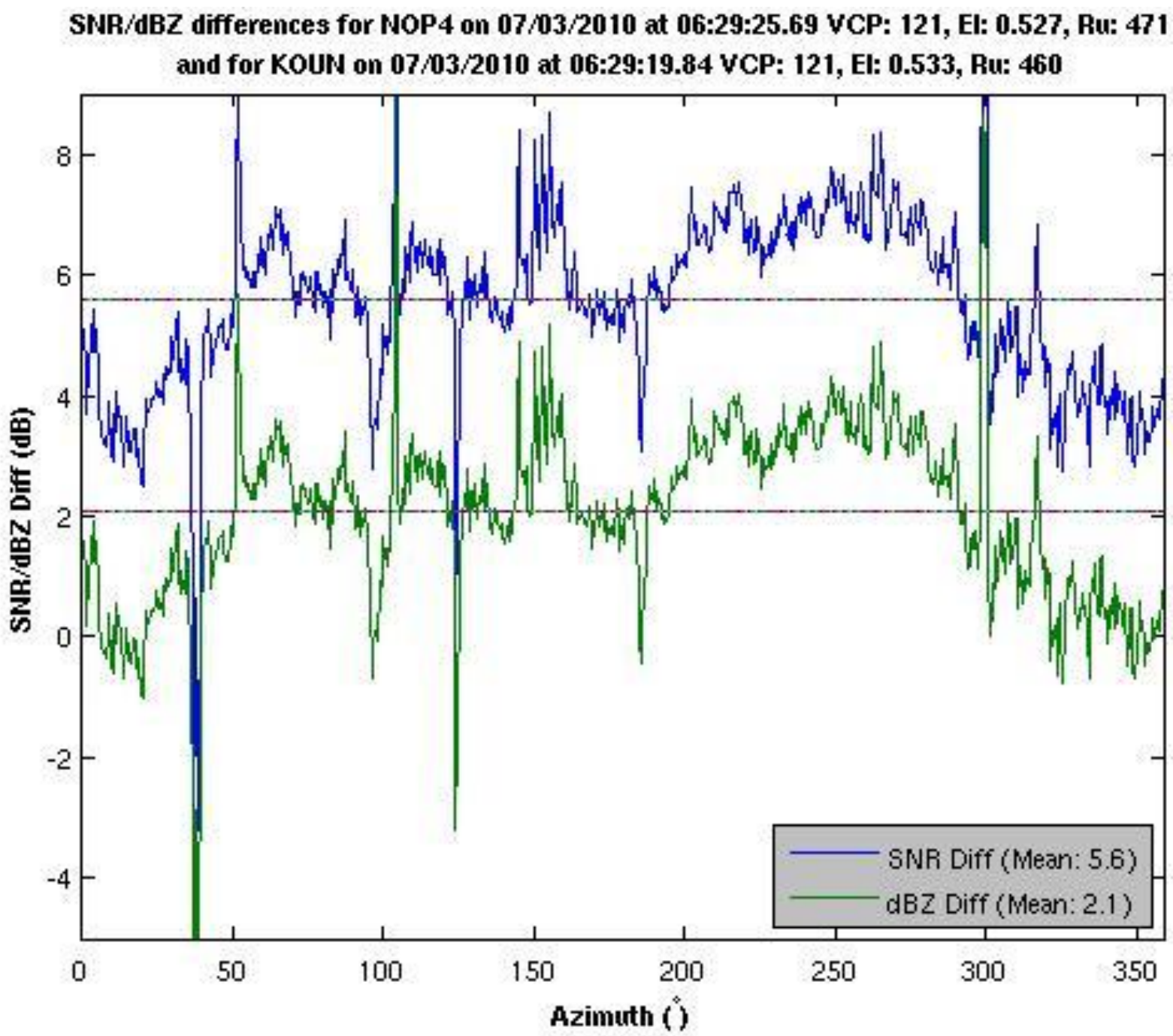

-20 10 -0+ 20 30 40 50 60 70
VCP 21
0.25 km, 0.5dAz
MX: 62dBZ
koun 0.5 Z 8bit Mon 23:25Z + koun 0.5 V 8bit Mon 23:25Z 21-Sep-09

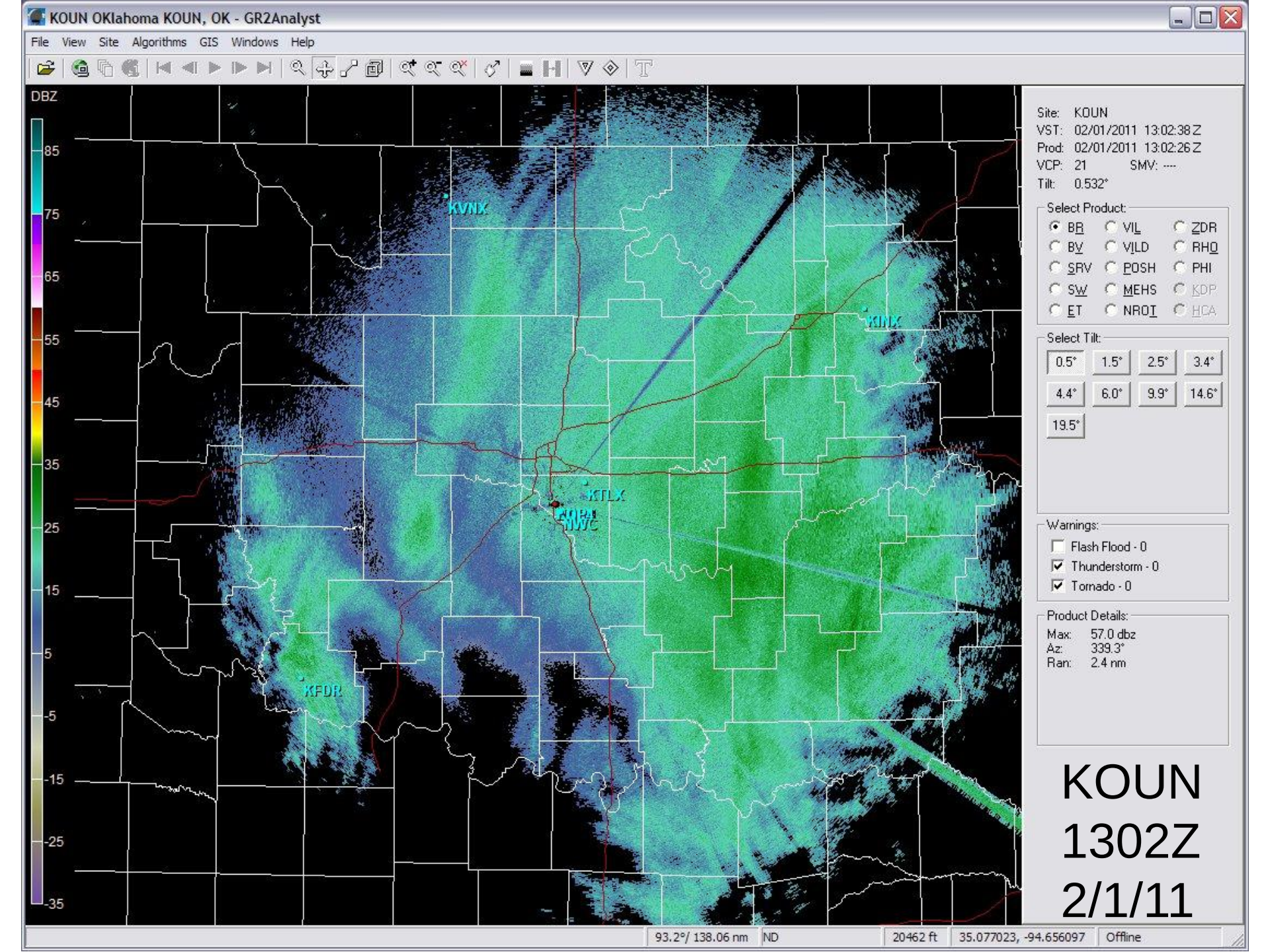

-20 10 -0+ 20 30 40 50 60 70
VCP 221
0.25 km, 0.5dAz
MX: 68dBZ
kcri 0.5 Z 8bit Mon 23:24Z + kcri 0.5 V 8bit Mon 23:24Z 21-Sep-09

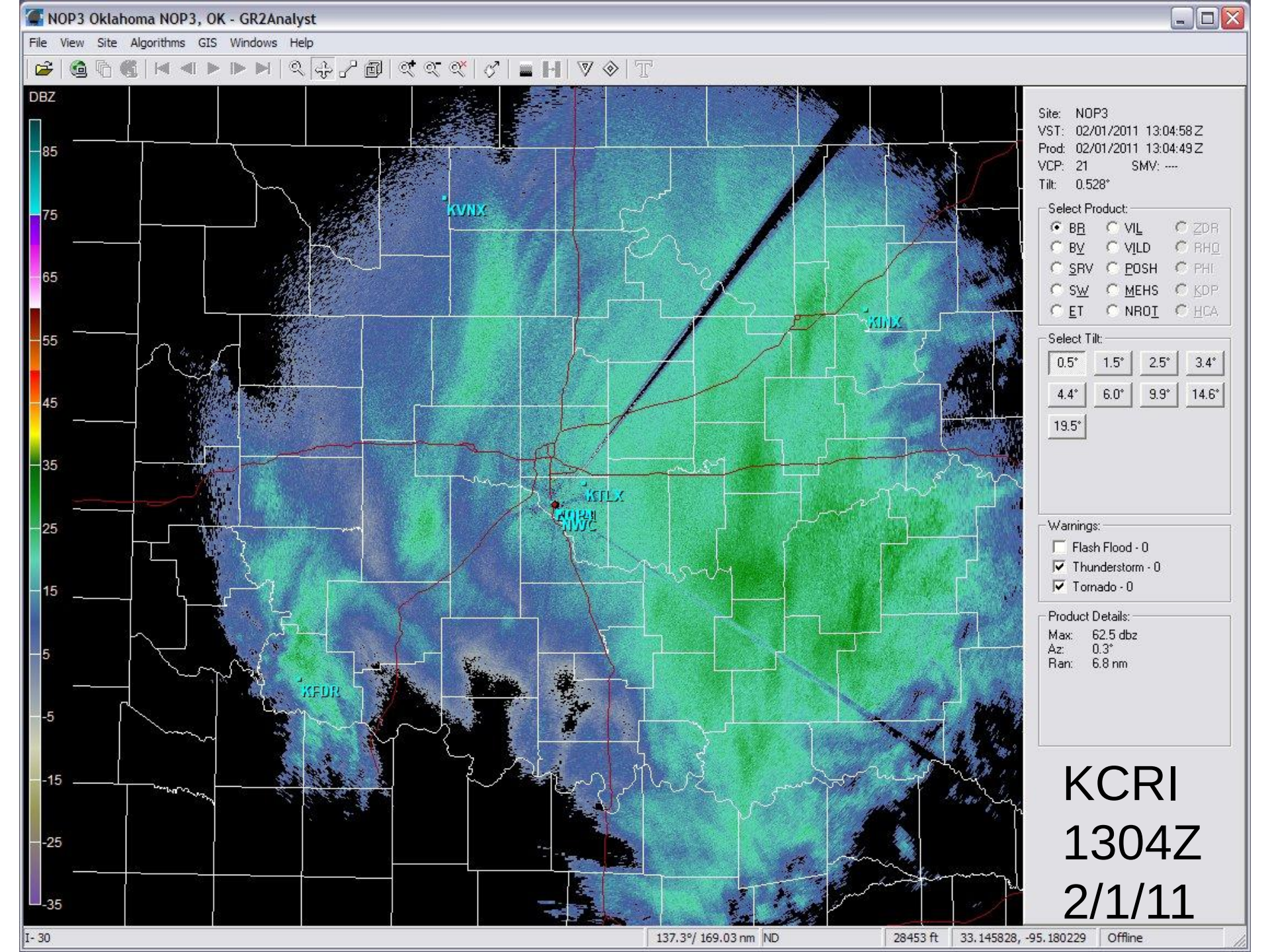
Resolved: Sensitivity/ Reflectivity Calibration Differences Between KOUN and KCRI


-20 10 10 20 30 40 50 60 70
VCP 121
0.25 km, 0.5dAz
MX: 62dBZ
KCRI
0.5 deg
Z
kcri 0.5 Z 8bit Sat 06:29Z + kcri 0.5 V Sat 06:29Z 03-Jul-10


-20 10 10 20 30 40 50 60 70
VCP 121
0.25 km, 0.5dAz
MX: 52dBZ
KOUN
0.5 deg
Z
koun 0.5 Z 8bit Sat 06:29Z + koun 0.5 V 8bit Sat 06:29Z 03-Jul-10

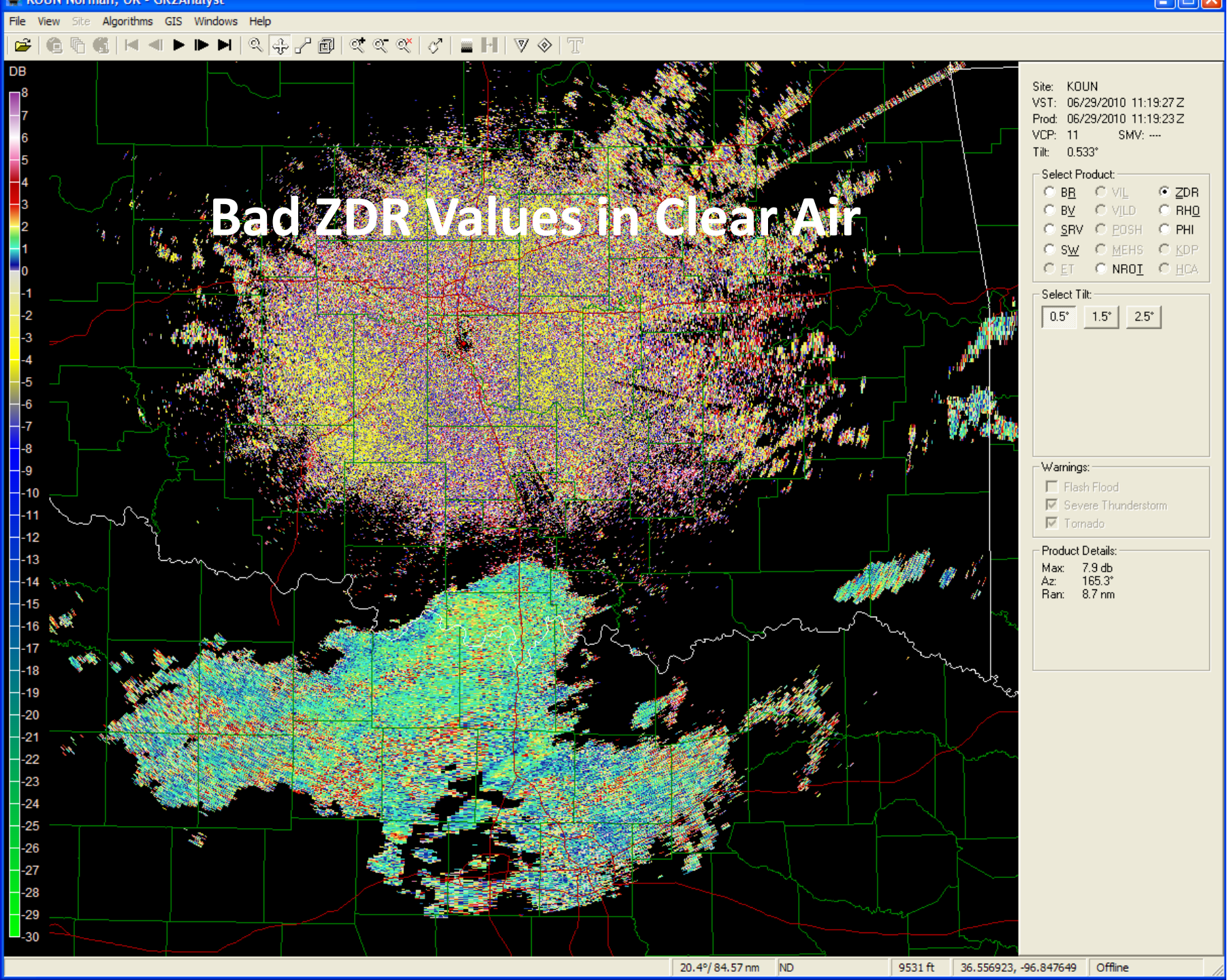

SNR/dBZ differences for NOP4 on 07/03/2010 at 06:29:25.69 VCP: 121, El: 0.527, Ru: 471
and for KOUN on 07/03/2010 at 06:29:19.84 VCP: 121, El: 0.533, Ru: 460
SNR/dBZ Diff (dB)
8
6
4
2
0
-2
-4
0
50
100
150
200
250
300
350
Azimuth (°)
SNR Diff (Mean: 5.6)
dBZ Diff (Mean: 2.1)

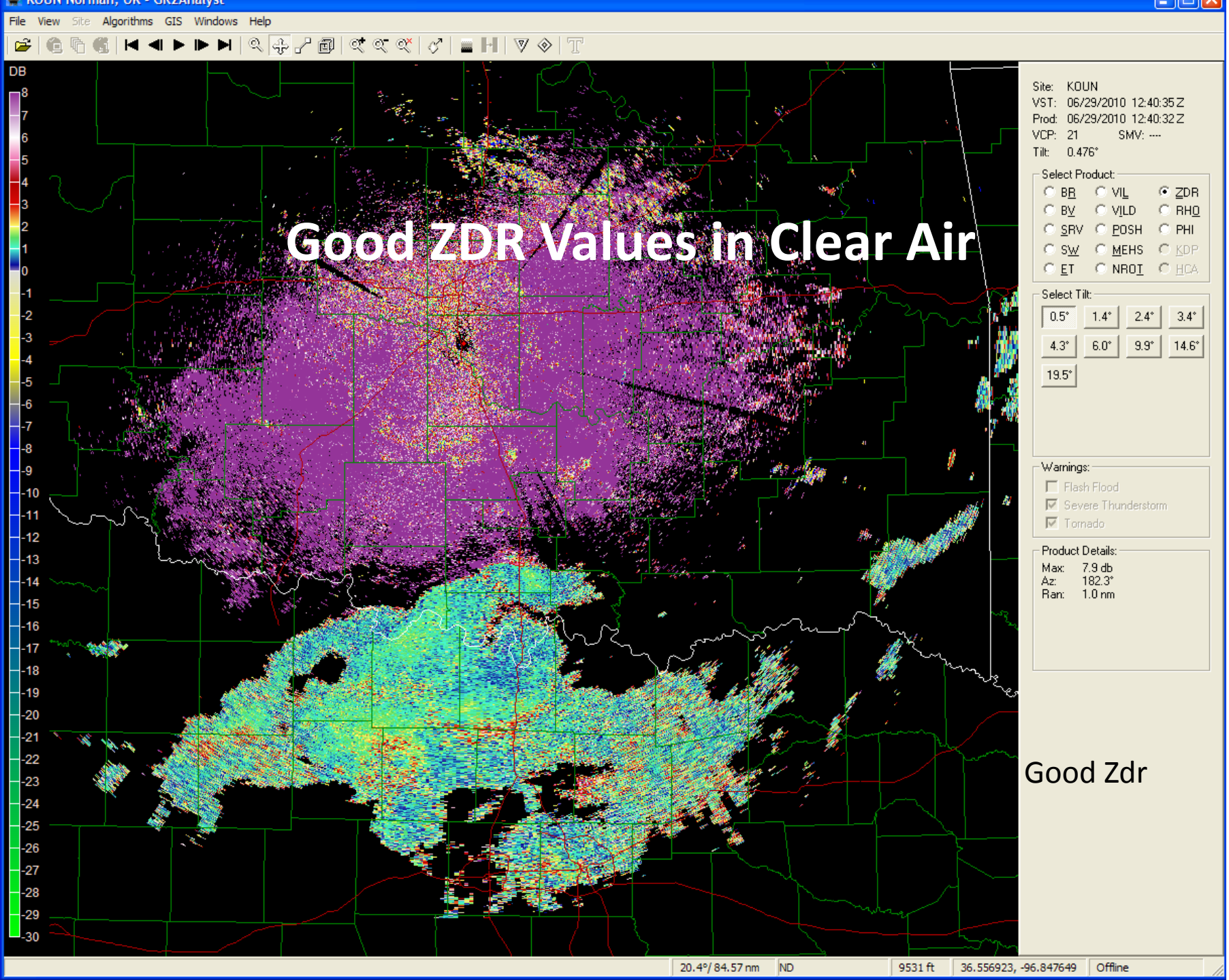

KOUN OKlahoma KOUN, OK - GR2Analyst
File View Site Algorithms GIS Windows Help
DBZ
85
75
65
55
45
35
25
15
5
-5
-15
-25
-35
KVNX
KINX
KTLX
KFDR
Site: KOUN
VST: 02/01/2011 13:02:38 Z
Prod: 02/01/2011 13:02:26 Z
VCP: 21 SMV: ---
Tilt: 0.532°
Select Product:
BR VIL ZDR
BV VILD RHO
SRV POSH PHI
SW MEHS KDP
ET NROT HCA
Select Tilt:
0.5° 1.5° 2.5° 3.4°
4.4° 6.0° 9.9° 14.6°
19.5°
Warnings:
Flash Flood - 0
Thunderstorm - 0
Tornado - 0
Product Details:
Max: 57.0 dbz
Az: 339.3°
Ran: 2.4 nm
KOUN
1302Z
2/1/11
93.2°/ 138.06 nm
ND
20462 ft
35.077023, -94.656097
Offline


NOP3 Oklahoma NOP3, OK - GR2Analyst
File View Site Algorithms GIS Windows Help
DBZ
85
75
65
55
45
35
25
15
5
-5
-15
-25
-35
KVNX
KTLX
KINX
KFDR
Site: NOP3
VST: 02/01/2011 13:04:58 Z
Prod: 02/01/2011 13:04:49 Z
VCP: 21 SMV: ---
Tilt: 0.528°
Select Product:
BR VIL ZDR
BV VILD RHO
SRV POSH PHI
SW MEHS KDP
ET NROT HCA
Select Tilt:
0.5° 1.5° 2.5° 3.4°
4.4° 6.0° 9.9° 14.6°
19.5°
Warnings:
Flash Flood - 0
Thunderstorm - 0
Tornado - 0
Product Details:
Max: 62.5 dbz
Az: 0.3°
Ran: 6.8 nm
KCRI
1304Z
2/1/11
I- 30
137.3°/ 169.03 nm ND
28453 ft
33.145828, -95.180229
Offline

Resolved: Very high ZDR in clear air returns

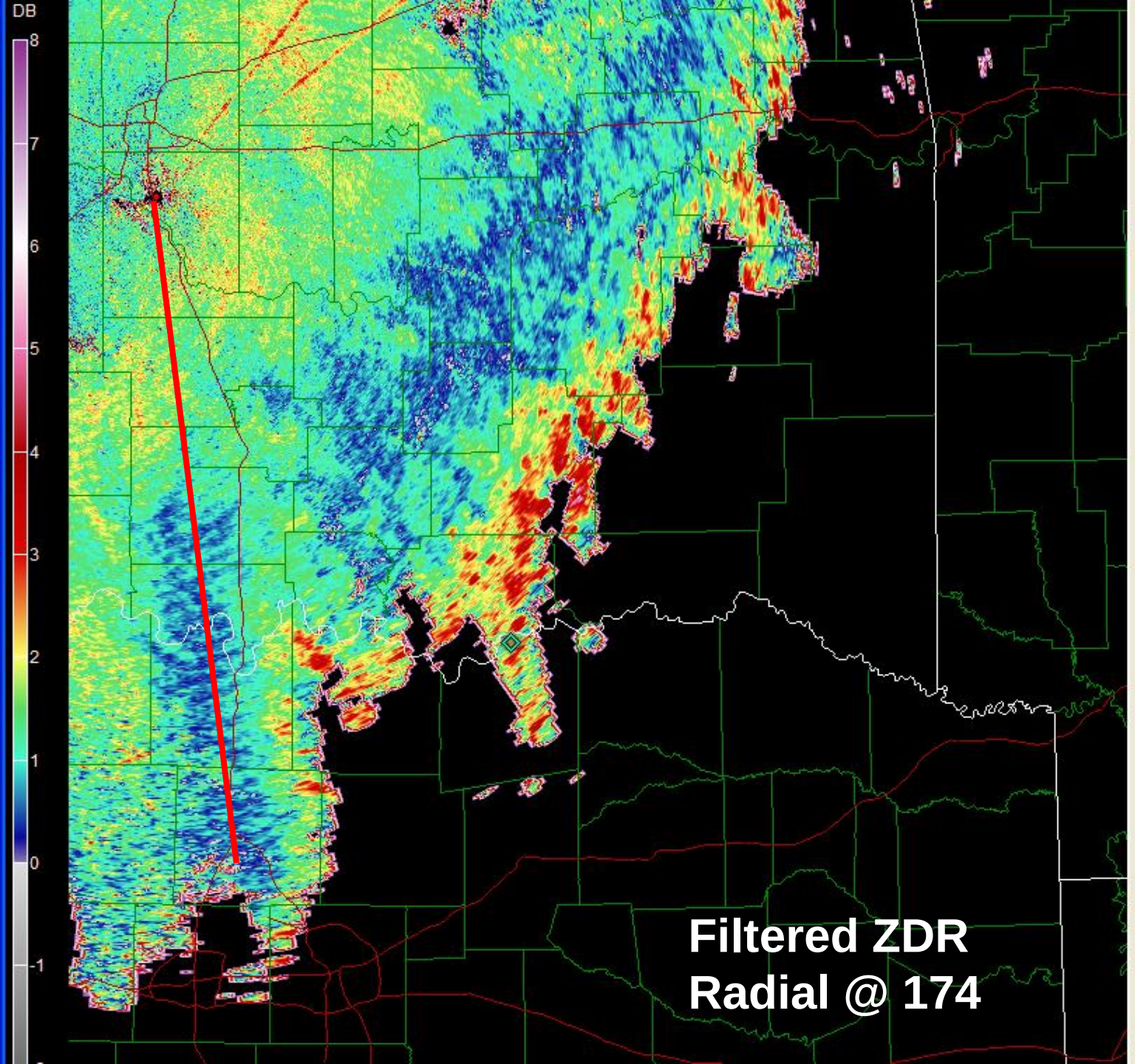
- Began on 6/29/10
- Persistent in all clear air returns since
- Does not seem to affect Zdr in weather
- Seen in all VCPs
- L-3/Baron investigated and resolved a scaling issue to properly cap ZDR values


KOUN Norman, OK - GR2Analyst
File View Site Algorithms GIS Windows Help
Bad ZDR Values in Clear Air
DB
8 7 6 5 4 3 2 1 0 -1 -2 -3 -4 -5 -6 -7 -8 -9 -10 -11 -12 -13 -14 -15 -16 -17 -18 -19 -20 -21 -22 -23 -24 -25 -26 -27 -28 -29 -30
Site: KOUN
VST: 06/29/2010 11:19:27 Z
Prod: 06/29/2010 11:19:23 Z
VCP: 11 SMV: ----
Tilt: 0.533°
Select Product:
BR VIL ZDR
BV VILD RHO
SRV PDSH PHI
SW MEHS KDP
ET NROT HCA
Select Tilt:
0.5° 1.5° 2.5°
Warnings:
Flash Flood
Severe Thunderstorm
Tornado
Product Details:
Max: 7.9 db
Az: 165.3°
Ran: 8.7 nm
20.4°/ 84.57 nm
ND
9531 ft
36.556923, -96.847649
Offline


KOUN Norman, OK - GR2Analyst
File View Site Algorithms GIS Windows Help
DB
8 7 6 5 4 3 2 1 0 -1 -2 -3 -4 -5 -6 -7 -8 -9 -10 -11 -12 -13 -14 -15 -16 -17 -18 -19 -20 -21 -22 -23 -24 -25 -26 -27 -28 -29 -30
Good ZDR Values in Clear Air
Site: KOUN
VST: 06/29/2010 12:40:35Z
Prod: 06/29/2010 12:40:32Z
VCP: 21 SMV: ----
Tilt: 0.476°
Select Product:
BR VIL ZDR
BV VILD RHO
SRV POSH PHI
SW MEHS KDP
ET NROT HCA
Select Tilt:
0.5° 1.4° 2.4° 3.4°
4.3° 6.0° 9.9° 14.6°
19.5°
Warnings:
Flash Flood
Severe Thunderstorm
Tornado
Product Details:
Max: 7.9 db
Az: 182.3°
Ran: 1.0 nm
Good Zdr
20.4°/ 84.57 nm
ND
9531 ft
36.556923, -96.847649
Offline

Resolved: Fingerprint

- 15 June 2010, 0700Z
- Present in ZDR and PHI
- Faulty LNA was the problem



Site: KOUN
VST: 06/15/2010 07:00:40 Z
Prod: 06/15/2010 07:00:37 Z
VCP: 212 SMV: ----
Tilt: 0.534°

Select Product:

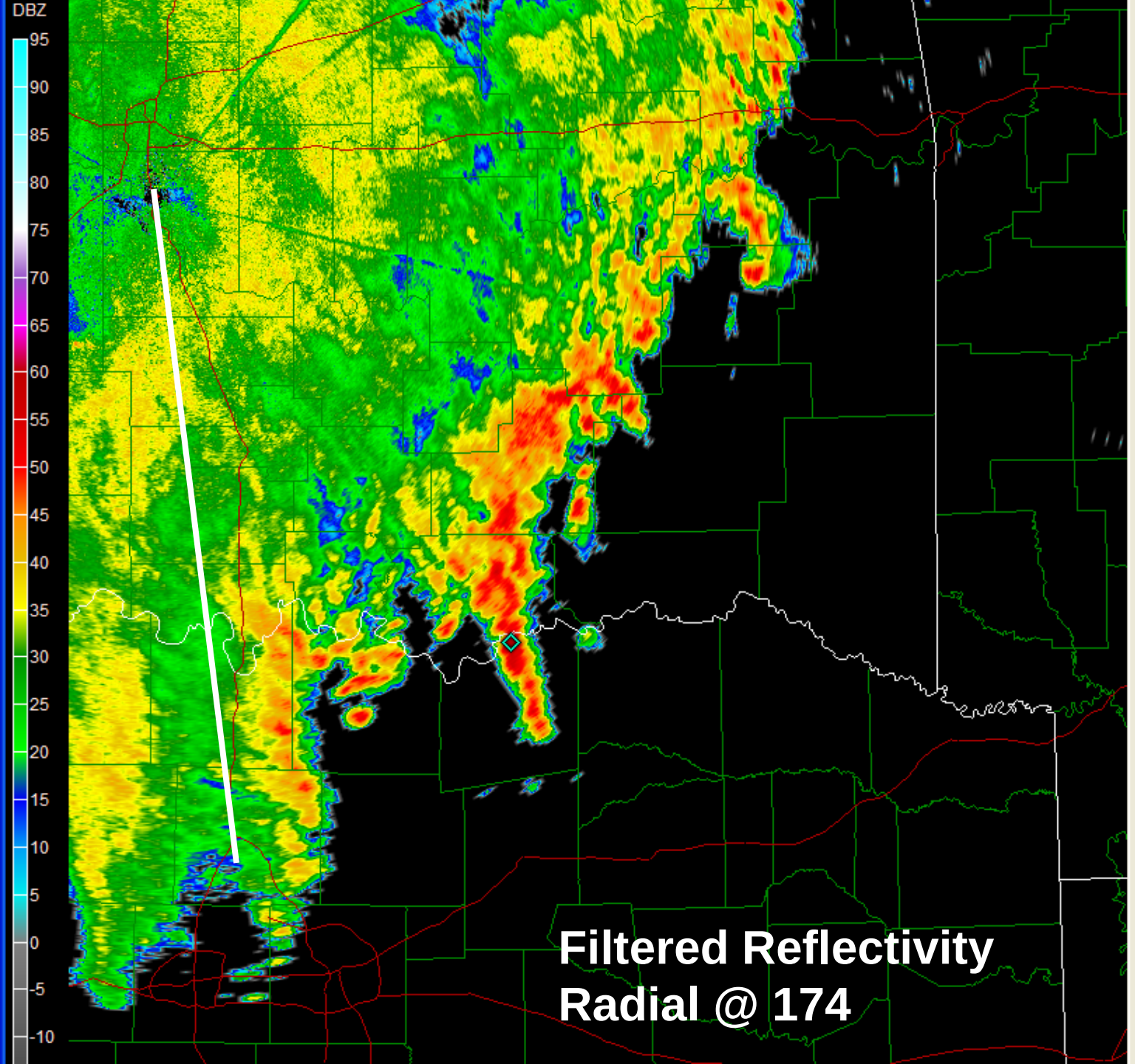
BR	VIL	ZDR
BV	VILD	RHO
SRV	POSH	PHI
SW	MEHS	KDP
ET	NROT	HCA

Select Tilt:

0.5°	0.9°	1.4°	1.9°
2.4°	3.2°	4.0°	5.2°
6.4°	8.0°	10.0°	12.5°
15.6°	19.5°		

Warnings:
- [x] Flash Flood - 2
- [x] Thunderstorm - 2
- [x] Tornado - 0

Product Details:
Max: 7.9 db
Az: 136.3°
Ran: 0.6 nm



Site: KOUN
VST: 06/15/2010 07:00:40 Z
Prod: 06/15/2010 07:00:37 Z
VCP: 212 SMV: ----
Tilt: 0.534°

Select Product:

(•) BR	( ) VIL	( ) ZDR
( ) BV	( ) VILD	( ) RHO
( ) SRV	( ) POSH	( ) PHI
( ) SW	( ) MEHS	( ) KDP
( ) ET	( ) NROT	( ) HCA

Select Tilt:

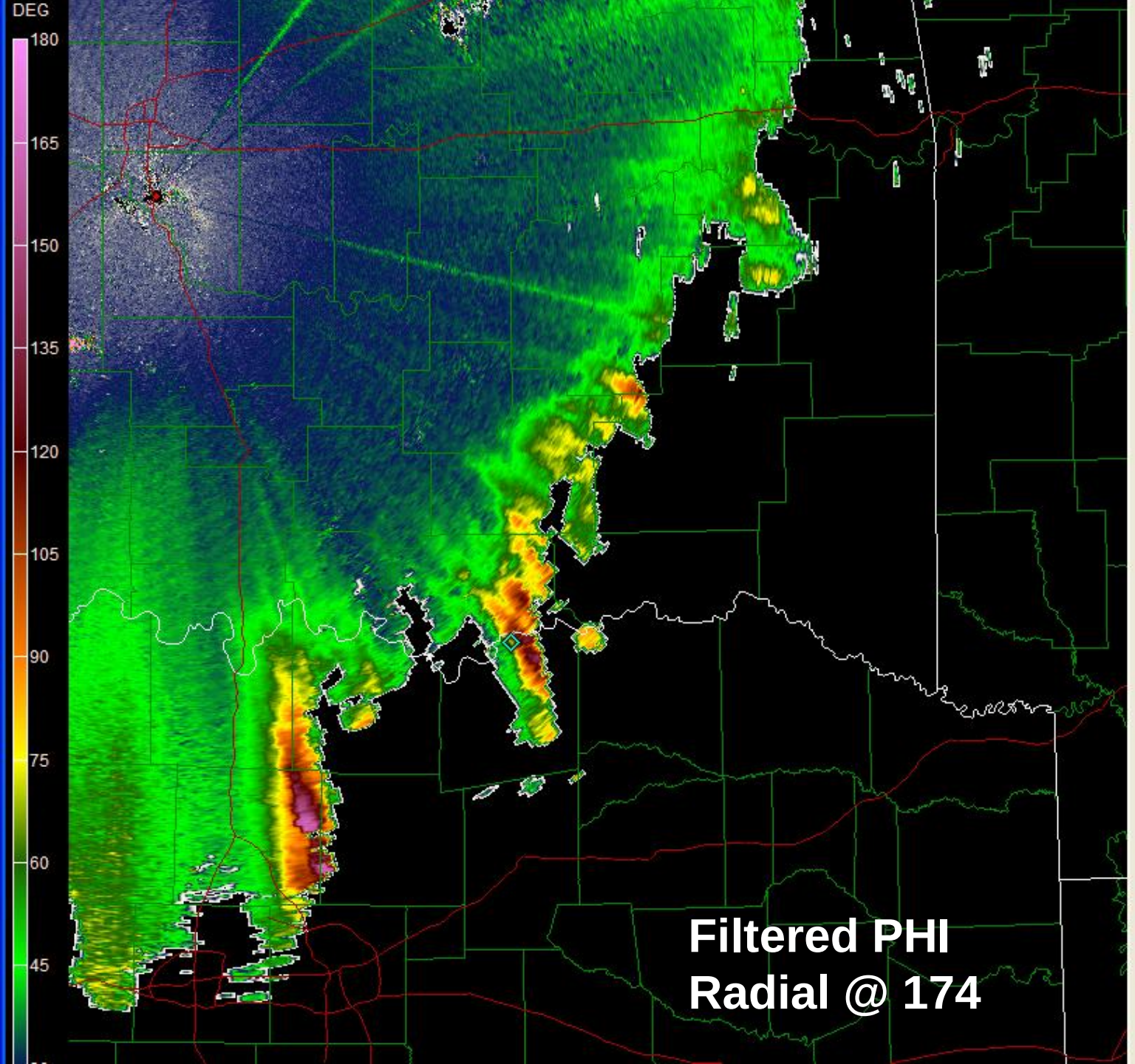
0.5°	0.9°	1.4°	1.9°
2.4°	3.2°	4.0°	5.2°
6.4°	8.0°	10.0°	12.5°
15.6°	19.5°		

Warnings:

- [x] Flash Flood - 2
- [x] Thunderstorm - 3
- [x] Tornado - 0

Product Details:

Max: 81.5 dbz
Az: 244.8°
Ran: 55.9 nm



Site: KOUN
VST: 06/15/2010 07:00:40 Z
Prod: 06/15/2010 07:00:37 Z
VCP: 212 SMV: ----
Tilt: 0.534°

Select Product:

BR	VIL	ZDR
BV	VILD	RHO
SRV	POSH	PHI
SW	MEHS	KDP
ET	NROT	HCA

Select Tilt:

0.5°	0.9°	1.4°	1.9°
2.4°	3.2°	4.0°	5.2°
6.4°	8.0°	10.0°	12.5°
15.6°	19.5°		

Warnings:
- [x] Flash Flood - 2
- [x] Thunderstorm - 3
- [x] Tornado - 0

Product Details:
Max: 360.0 deg
Az: 156.8°
Ran: 1.3 nm

Resolved DP Algorithm Science Issues

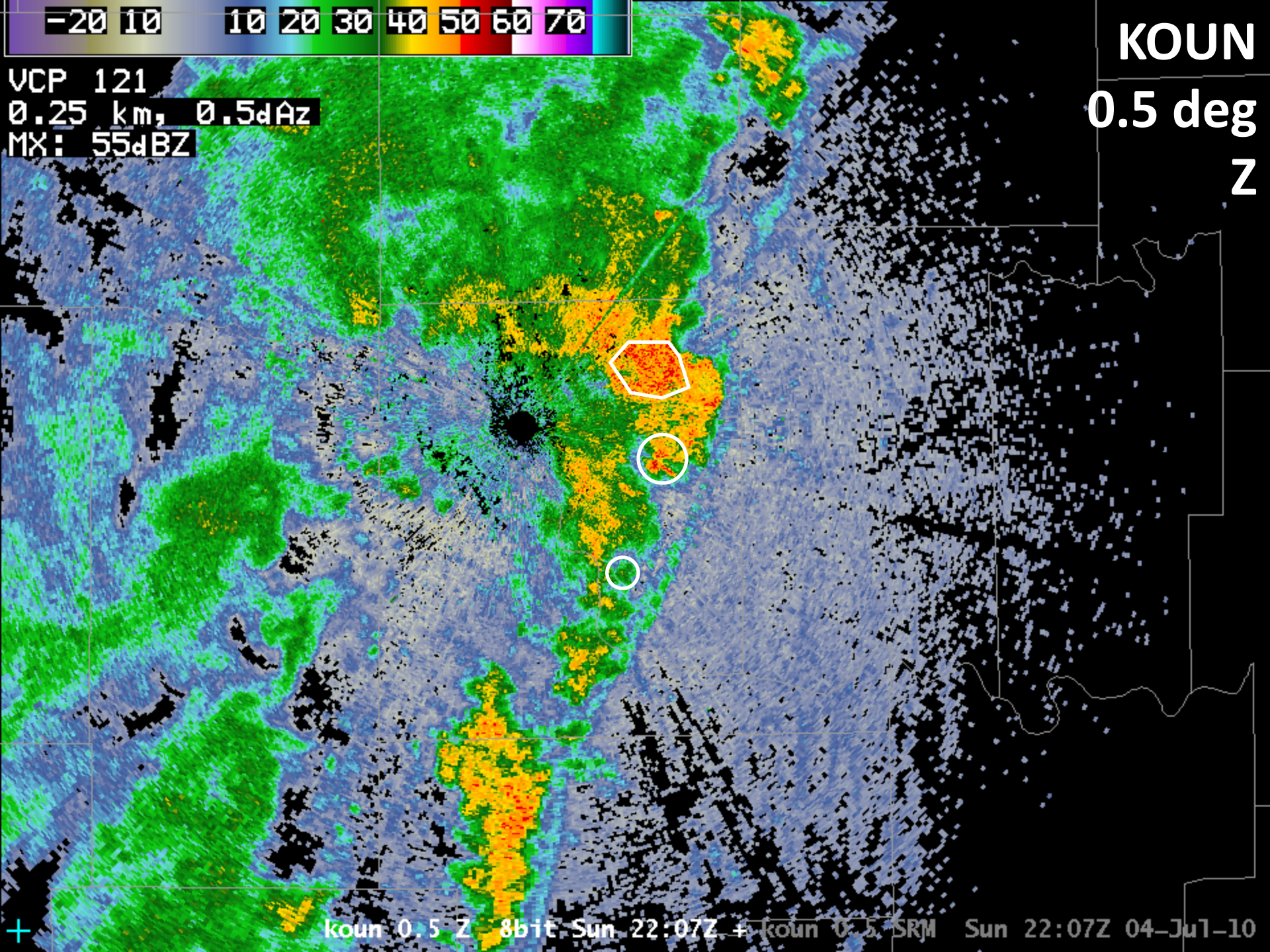
- Changes Submitted (Mark Fresch will cover in more detail)
  - DP QPE R(Z,ZDR) underestimates tropical rain
  - DP QPE rates much different for very small blockage compared to no blockage
  - Quick fix for attenuation/non-uniform beam filling: being tested
  - ROC Apps drafted AEL changes; ROC SW Eng implemented, additional testing under way
    - SMOOTHING BY THE DUAL POL PREPROCESSOR

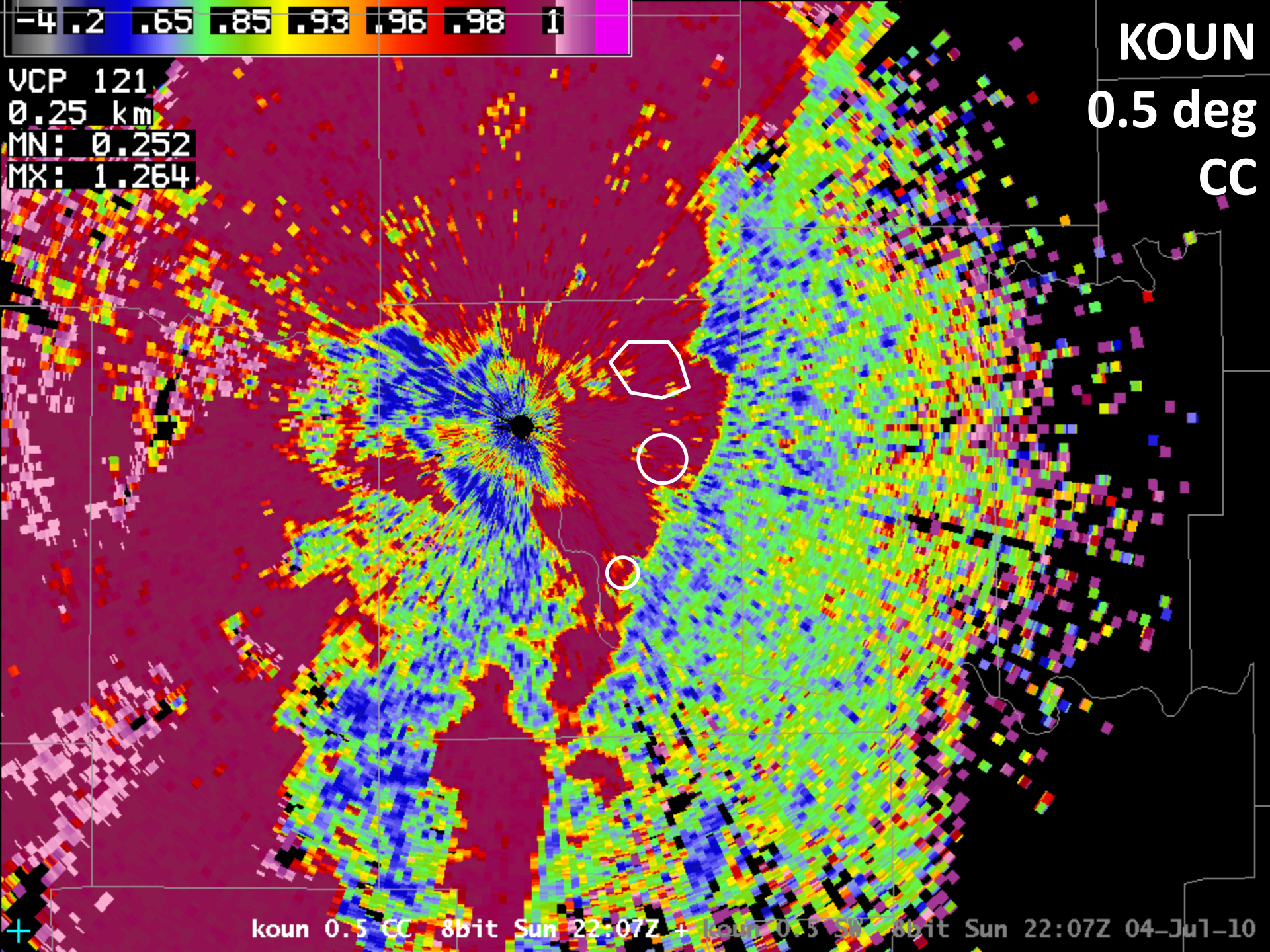
Dual-Pol Improved Capability Examples

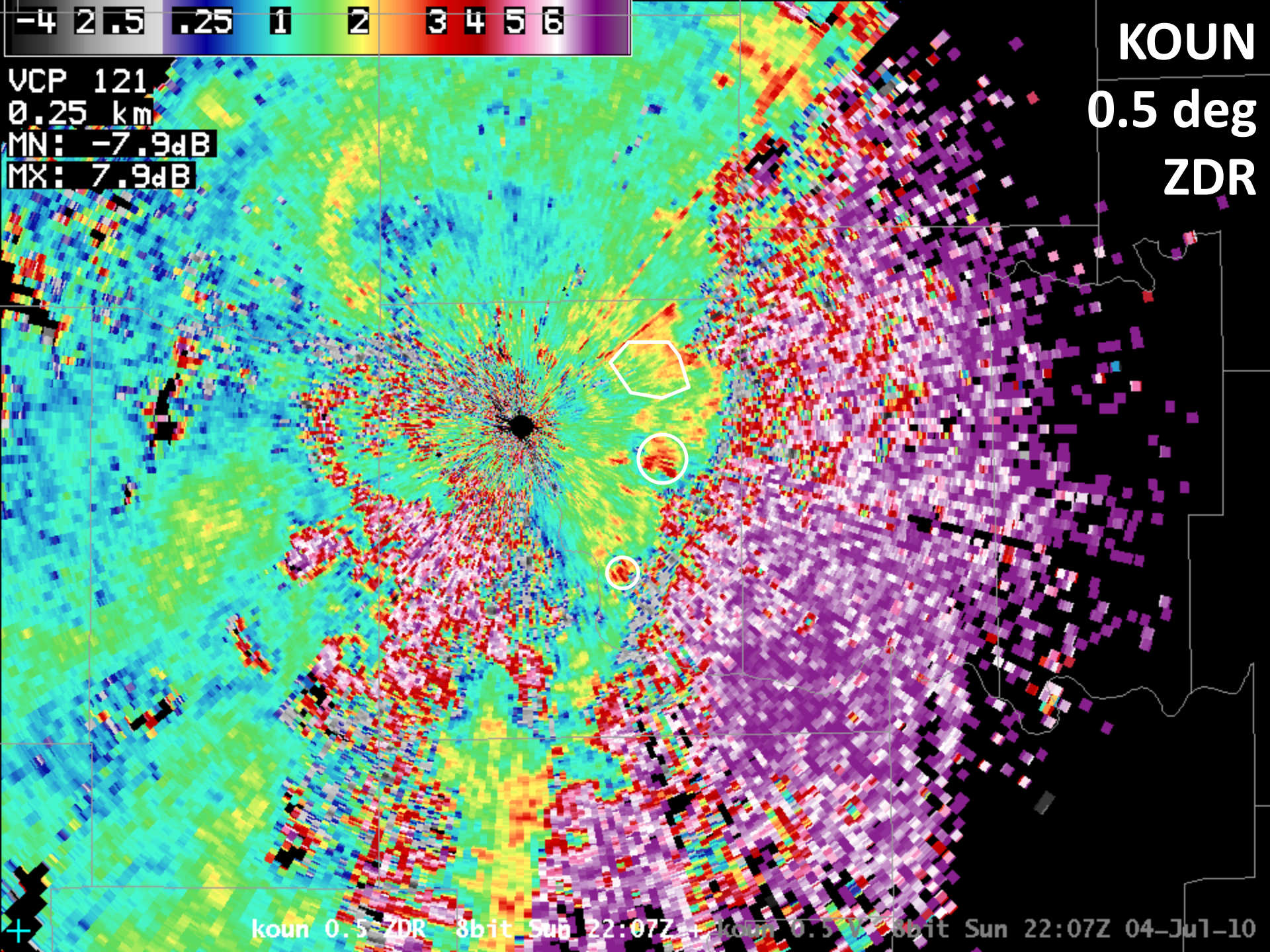
- DP Variables
- DP Algorithms
  - precipitation accumulation
  - melting layer
  - hydrometeor classification

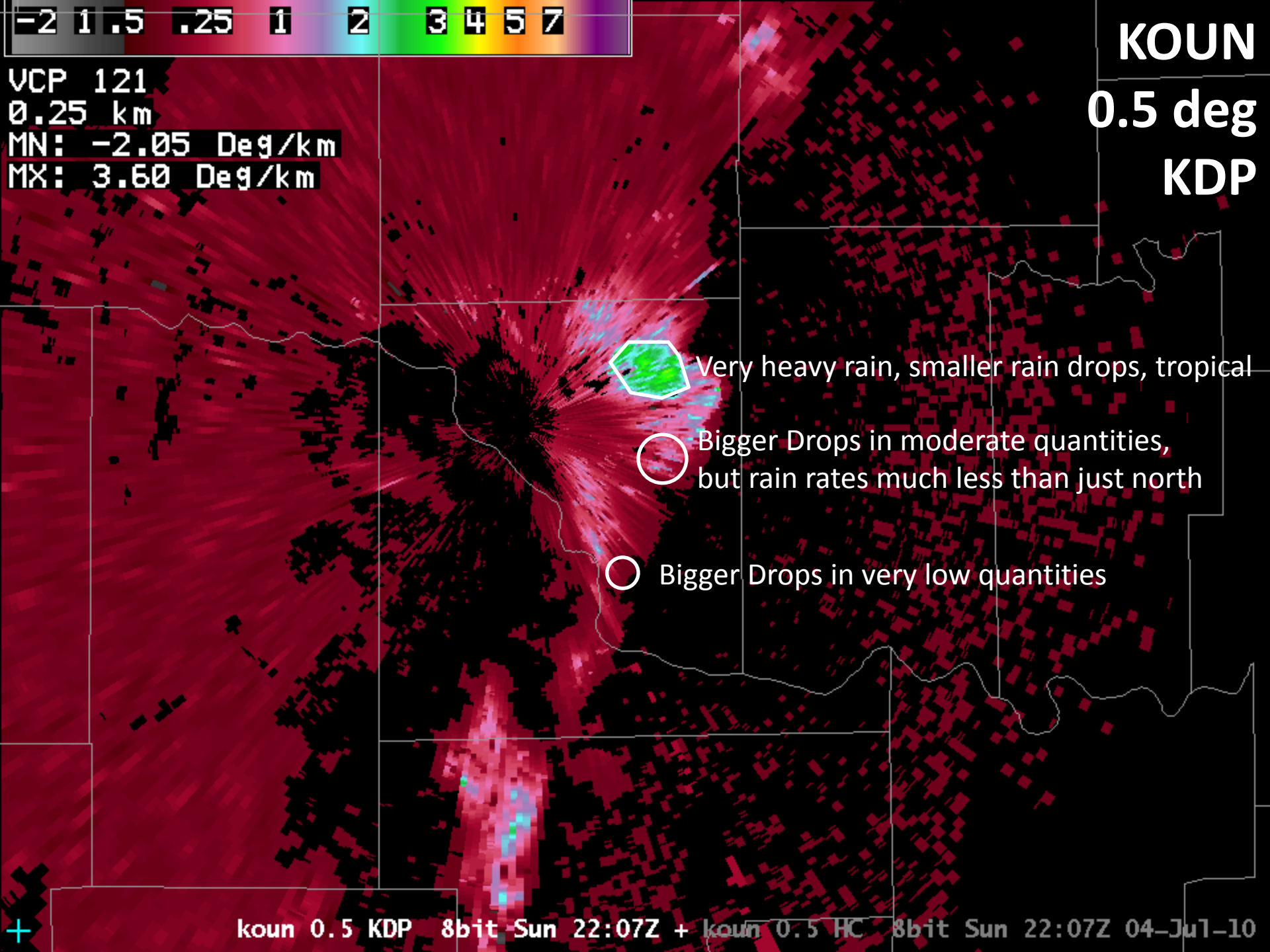
7/4/2010 KOUN: Improved Capability

- 2207 UTC
- VCP 121
- Bypass Map Clutter Filtering
- Linear convection
  - Heavy rain
  - Scarce lightning
  - Strong winds
  - Norman’s fireworks canceled


-20 10 10 20 30 40 50 60 70
VCP 121
0.25 km, 0.5dAz
MX: 55dBZ
KOUN
0.5 deg
Z
koun 0.5 Z 8bit Sun 22:07Z
koun 0.5 Z SRM Sun 22:07Z 04-Jul-10

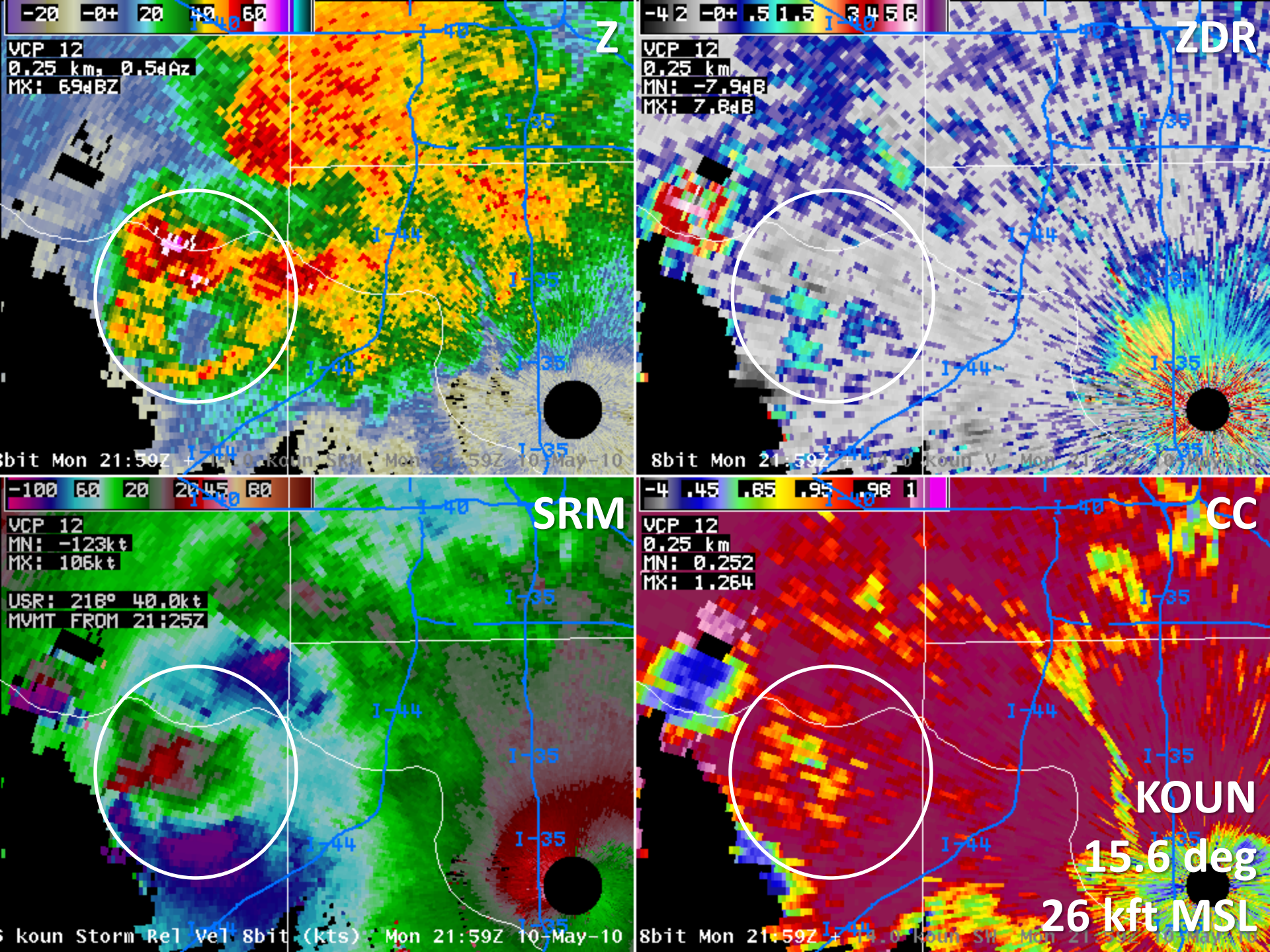

-4 .2 .65 .85 .93 .96 .98 1
VCP 121
0.25 km
MN: 0.252
MX: 1.264
KOUN
0.5 deg
CC
koun 0.5 CC 8bit Sun 22:07Z
koun 0.5 CC 8bit Sun 22:07Z 04-Jul-10


-4 2 .5 .25 1 2 3 4 5 6
VCP 121
0.25 km
MN: -7.9dB
MX: 7.9dB
KOUN
0.5 deg
ZDR
koun 0.5 ZDR 8bit Sun 22:07Z 04-Jul-10


-2 1 .5 .25 1 2 3 4 5 7
VCP 121
0.25 km
MN: -2.05 Deg/km
MX: 3.60 Deg/km
KOUN
0.5 deg
KDP
Very heavy rain, smaller rain drops, tropical
Bigger Drops in moderate quantities,
but rain rates much less than just north
Bigger Drops in very low quantities
koun 0.5 KDP 8bit Sun 22:07Z + koun 0.5 HC 8bit Sun 22:07Z 04-Jul-10

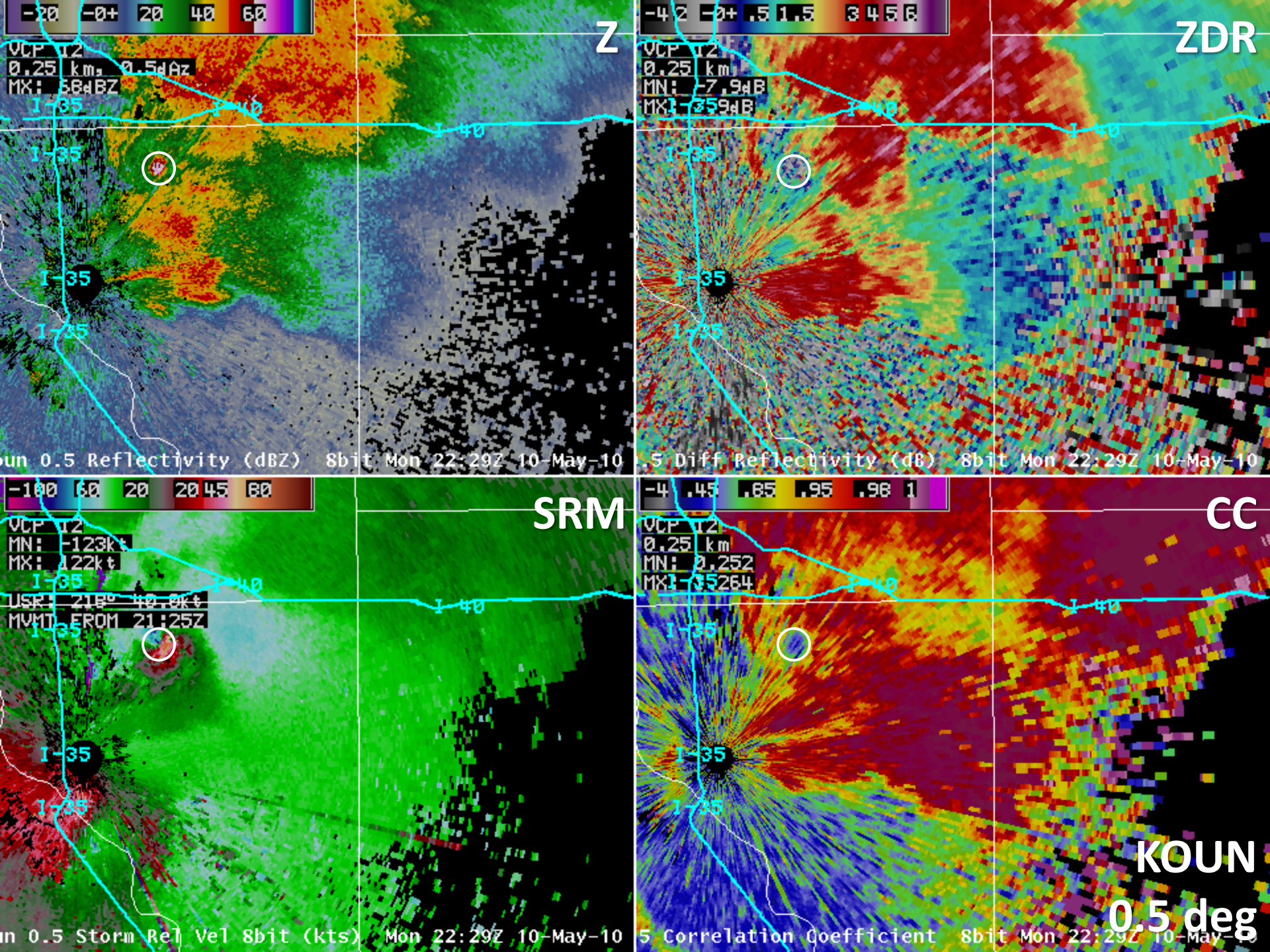
May 10, 2010 KOUN: Improved Capability

- 5/10/2010 2159 UTC
- Tornado outbreak
- Grapefruit hail
- Second best updraft ever seen by Les Lemon & Paul Schlatter

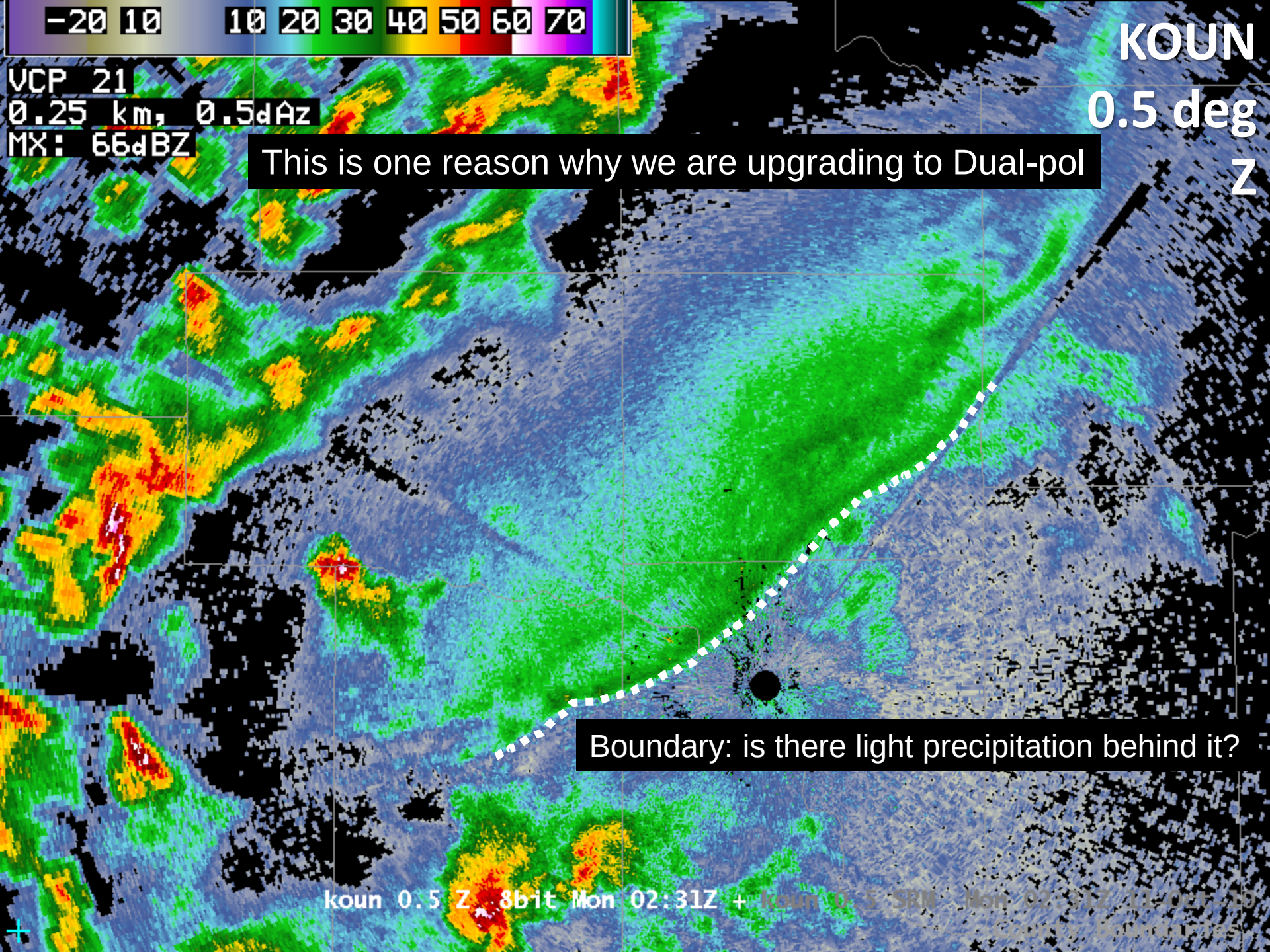

-20 -0+ 20 40 60
VCP 12
0.25 km, 0.5dAz
MX: 69dBZ
Z
I-40
I-44
I-35
8bit Mon 21:59Z
-4 2 -0+ .5 1.5 3 4 5 6
VCP 12
0.25 km
MN: -7.9dB
MX: 7.8dB
ZDR
I-40
I-44
I-35
8bit Mon 21:59Z
-100 60 20 20 45 80
VCP 12
MN: -123kt
MX: 106kt
USR: 218° 40.0kt
MVMT FROM 21:25Z
SRM
I-40
I-44
I-35
koun Storm Rel Vel 8bit (kts) Mon 21:59Z 10-May-10
-4 .45 .65 .95 .98 1
VCP 12
0.25 km
MN: 0.252
MX: 1.264
CC
I-40
I-44
I-35
KOUN
15.6 deg
26 kft MSL
8bit Mon 21:59Z

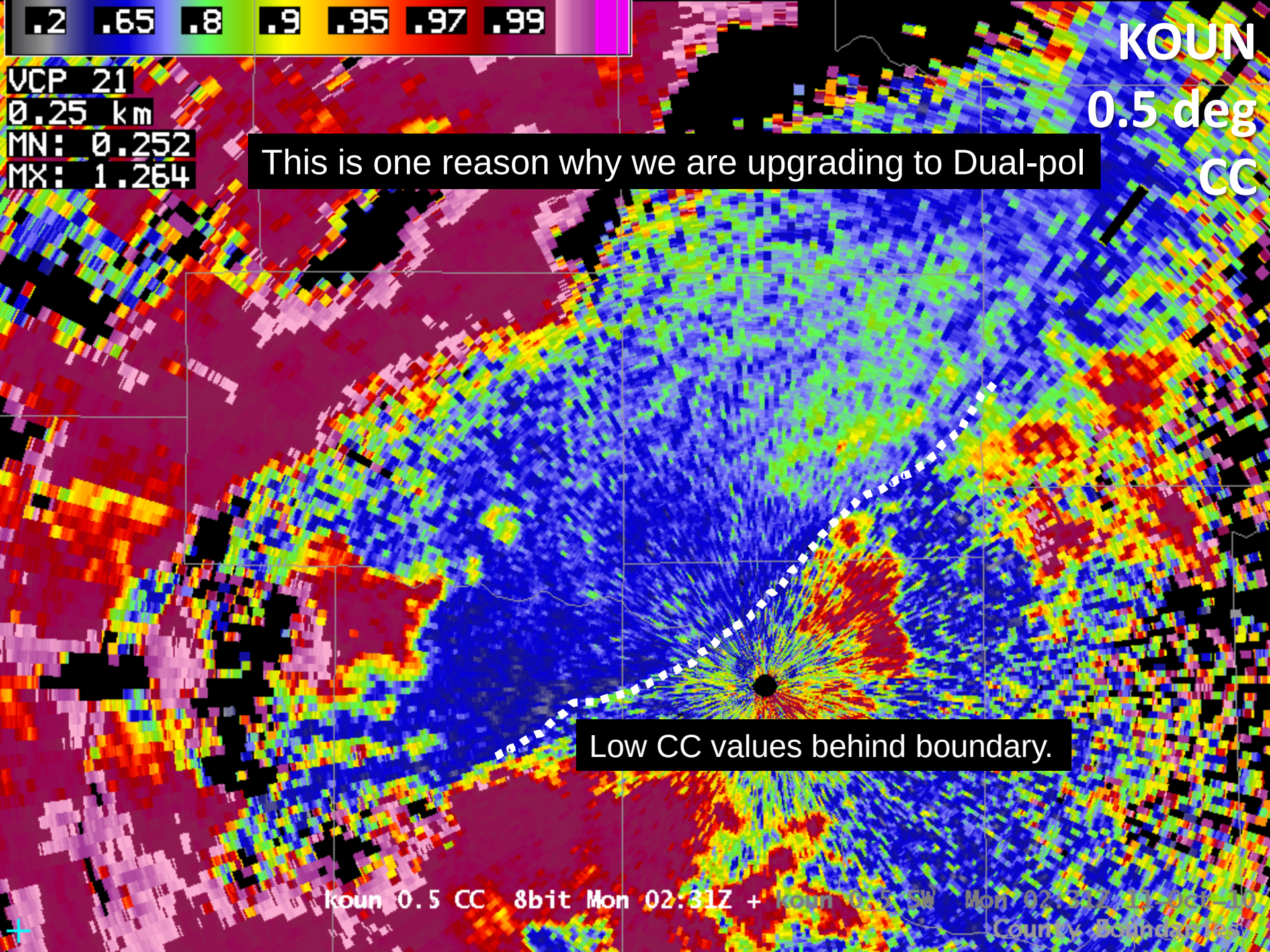
Tornado Debris Balls: Improved Capability

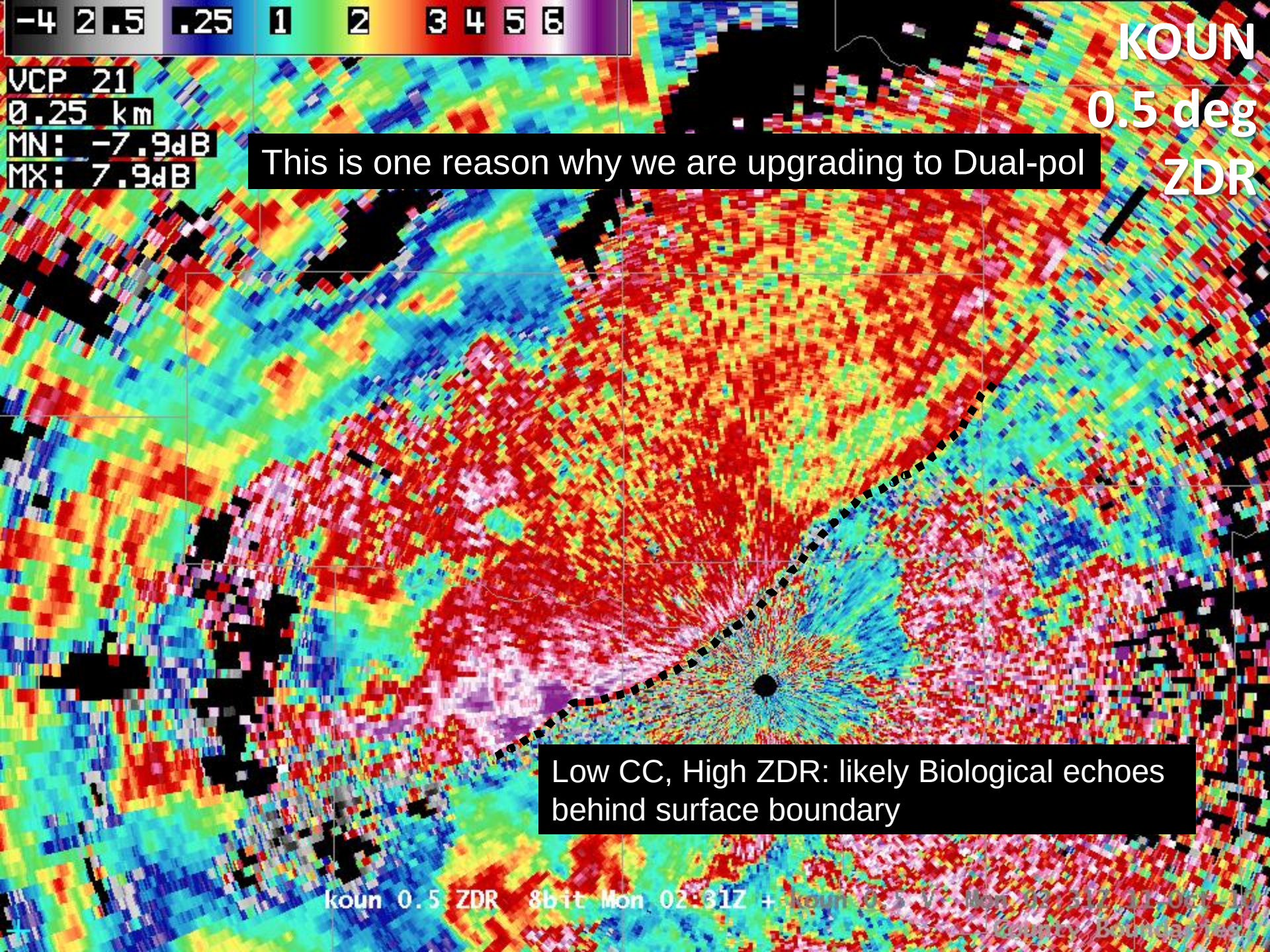
- May 10th 2229 UTC
- Low CC and Low ZDR values within tornado debris balls (white circles)


Z
ZDR
SRM
CC
KOUN
0.5 deg

DP Variables Differentiate Scatterers: Improved Capability


-20 10 10 20 30 40 50 60 70
VCP 21
0.25 km, 0.5dAz
MX: 66dBZ
KOUN
0.5 deg
Z
This is one reason why we are upgrading to Dual-pol
Boundary: is there light precipitation behind it?
koun 0.5 Z 8bit Mon 02:31Z


.2 .65 .8 .9 .95 .97 .99
VCP 21
0.25 km
MN: 0.252
MX: 1.264
KOUN
0.5 deg
CC
This is one reason why we are upgrading to Dual-pol
Low CC values behind boundary.
koun 0.5 CC 8bit Mon 02:31Z


-4 2.5 .25 1 2 3 4 5 6
VCP 21
0.25 km
MN: -7.9dB
MX: 7.9dB
KOUN
0.5 deg
ZDR
This is one reason why we are upgrading to Dual-pol
Low CC, High ZDR: likely Biological echoes behind surface boundary
koun 0.5 ZDR 8bit Mon 02:31Z

DP Algorithms Improved Capability

- Good base data for algorithm evaluation not provided until mid-May 2010
- 12 cases initially evaluated
  - Several issues identified with the Preprocessor, HCA, QPE, and ZDR calibration
  - Since then, OHD and ROC have been working with NSSL to refine the algorithms
- Even without all the issues fixed, there is evidence that DP QPE outperforms the PPS in the following situations:
  - removing non-precipitation echoes
  - mitigating hail contamination
  - Identifying the bright band.

Remaining Issues

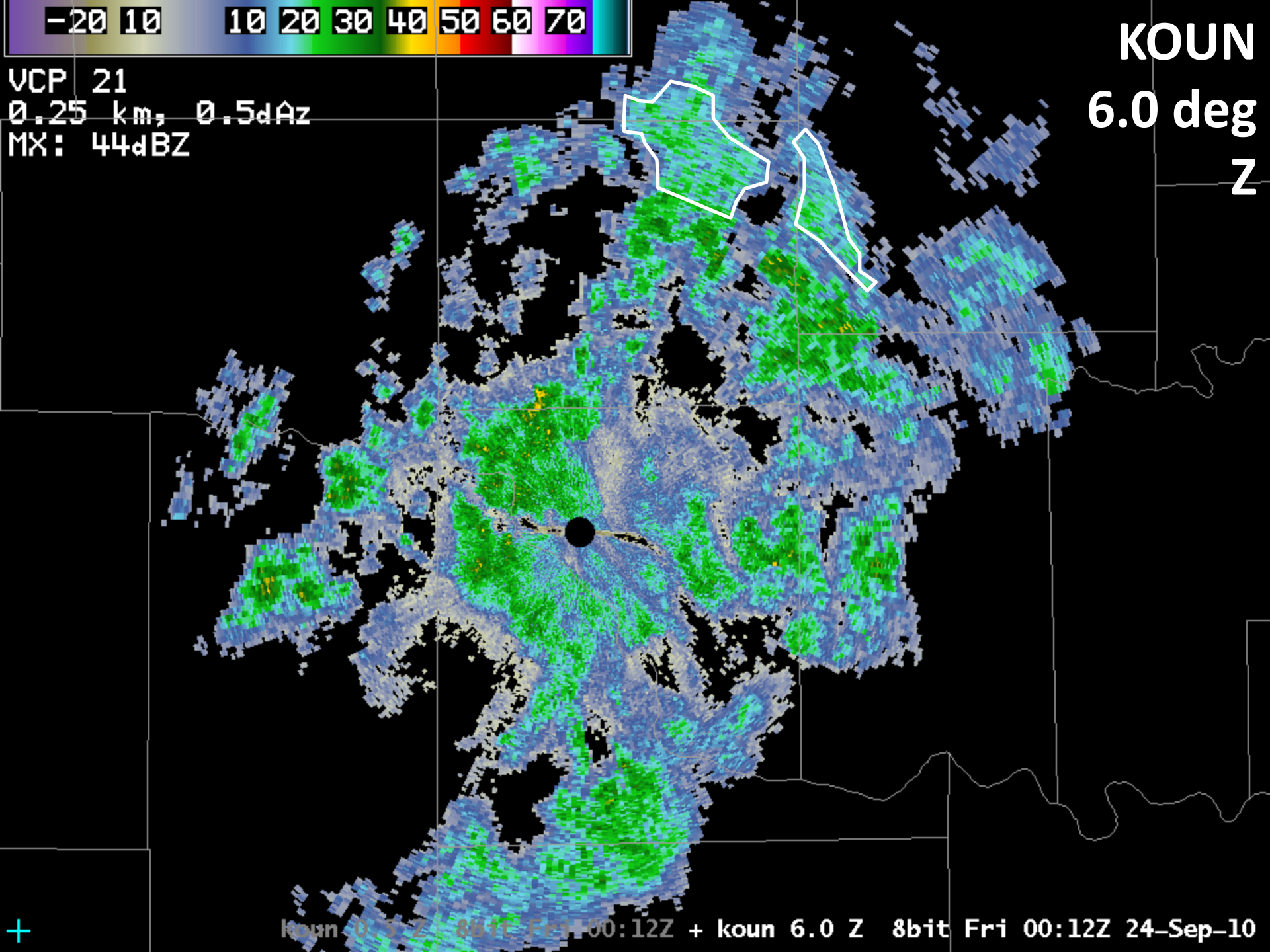
- Algorithm Refinement Issues
- ZDR Evaluation

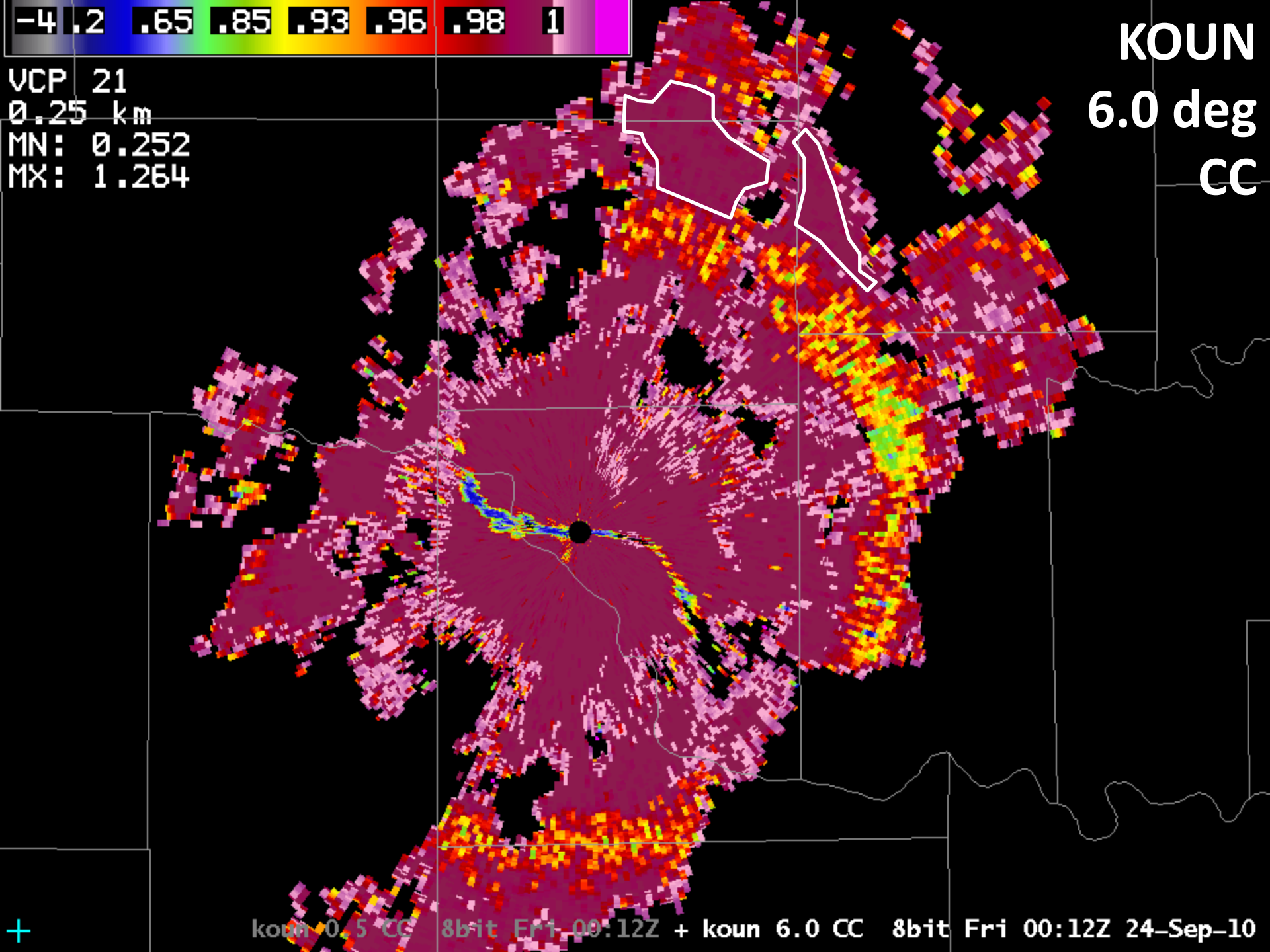
Remaining DP Algorithm Science Issues

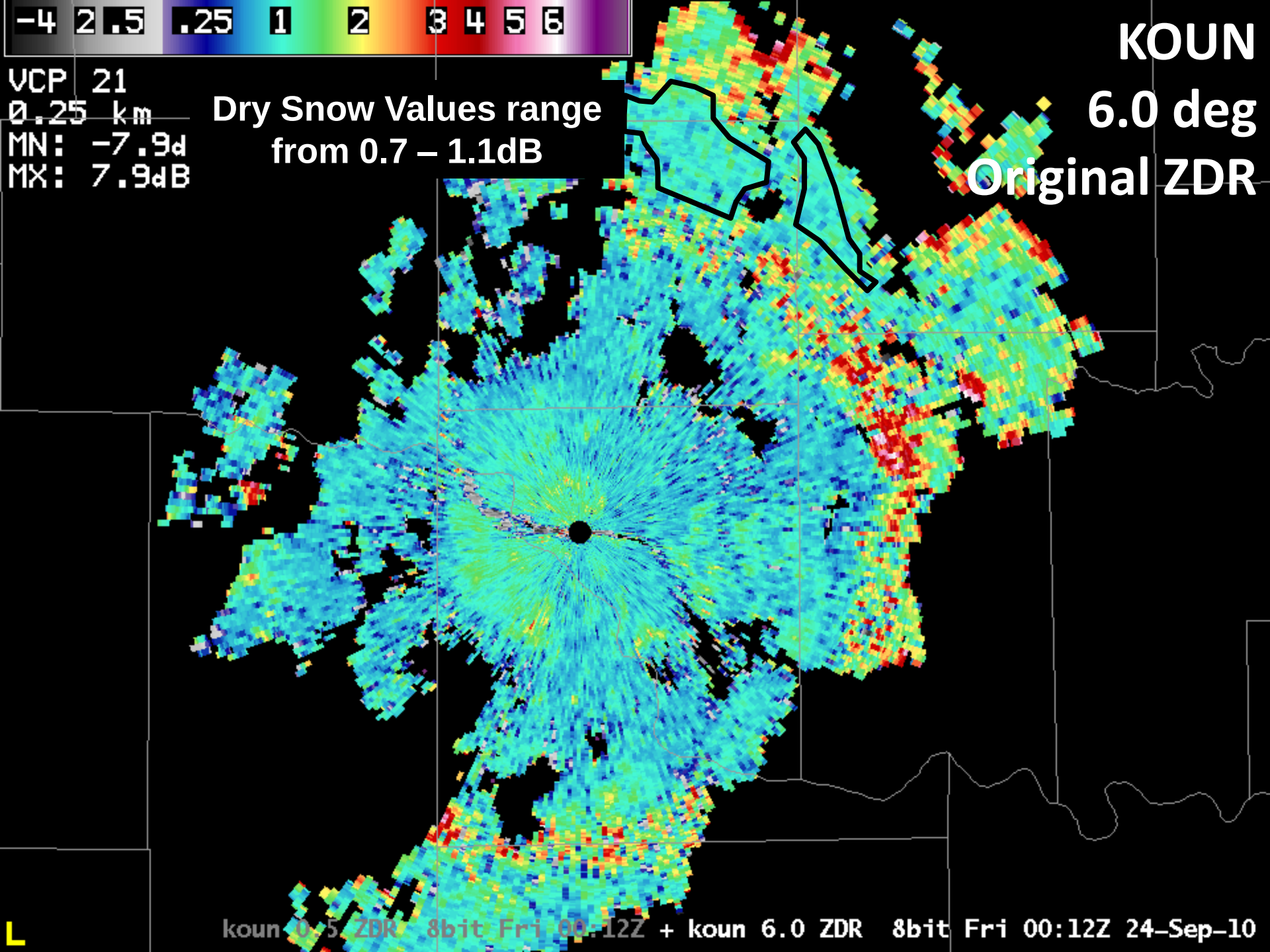
- Mark Fresch will cover in more detail
  - QPE won't work properly without ZDR calibrated to 0.1 dB
  - Biota Misclassified as Big Drops
  - Accumulation Discontinuity at Melting Layer
  - HCA mis-classifies non-precipitating echoes in some cases

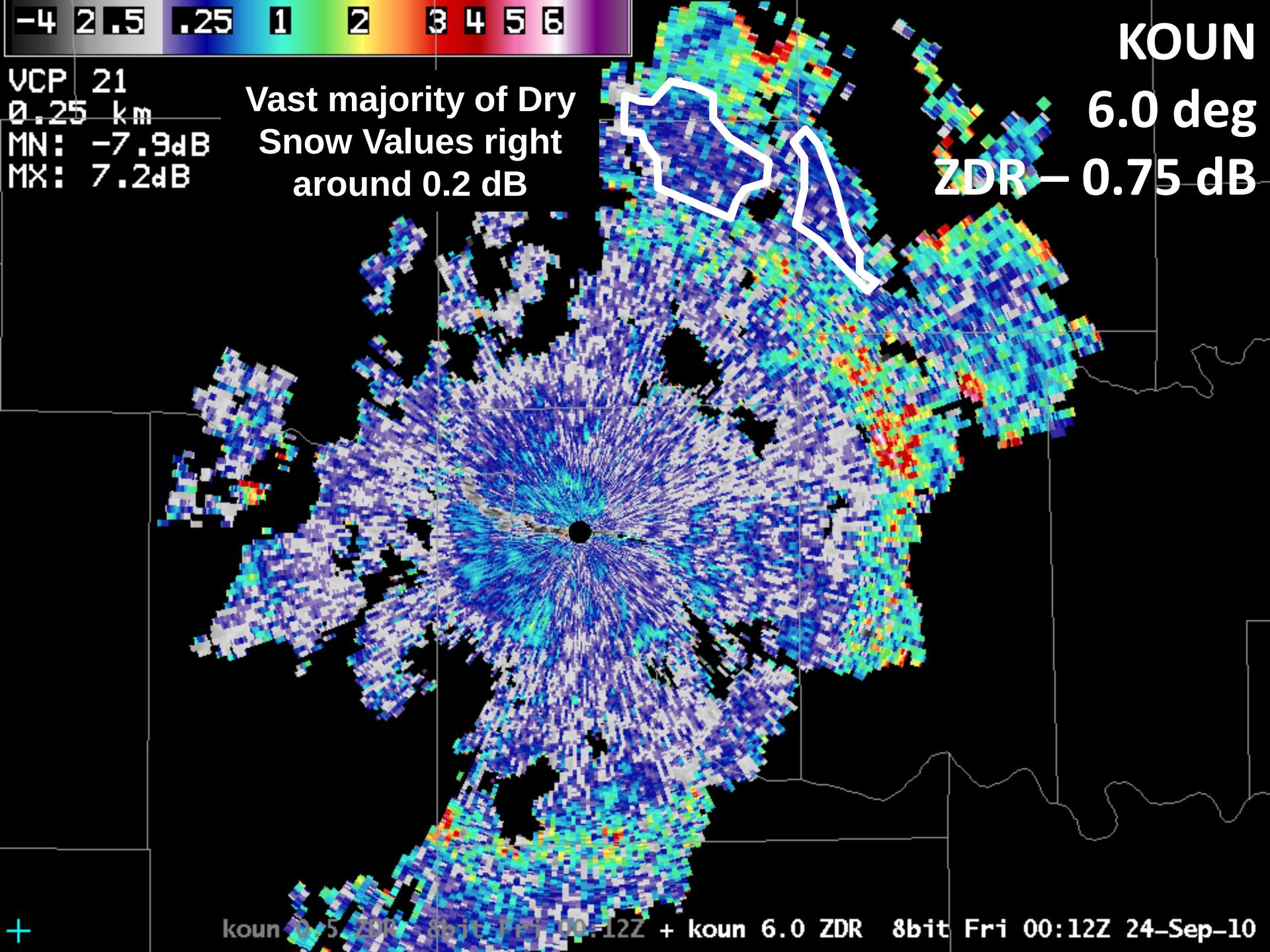
Remaining ZDR Calibration Issue

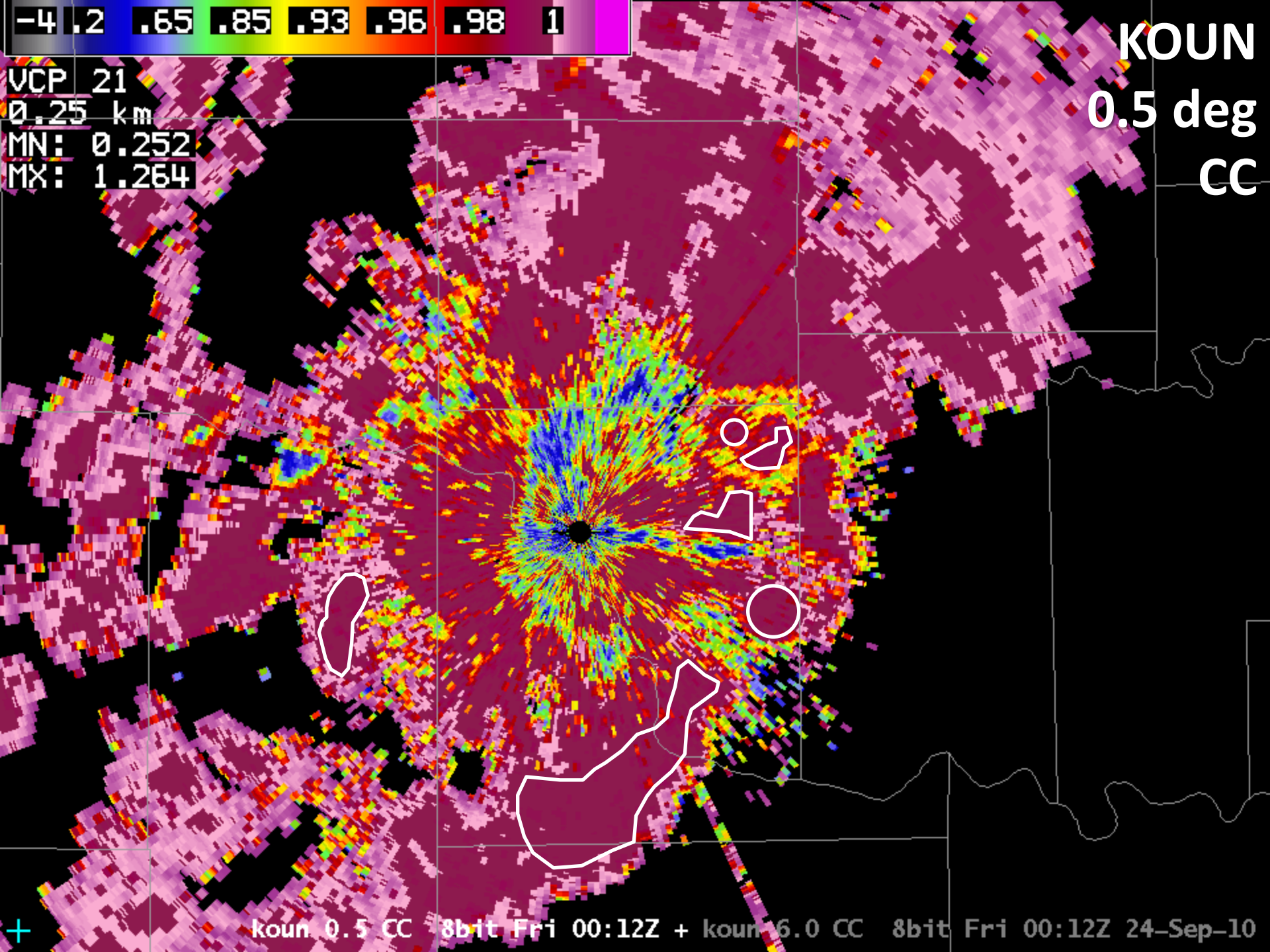
- Subjective human analysis ZDR evaluation
- 9/23/10: 0012 UTC
- VCP 21
- Bypass map clutter filtering
- Light stratiform rain across much of Oklahoma. Essentially the poster child for being able to check for ZDR bias

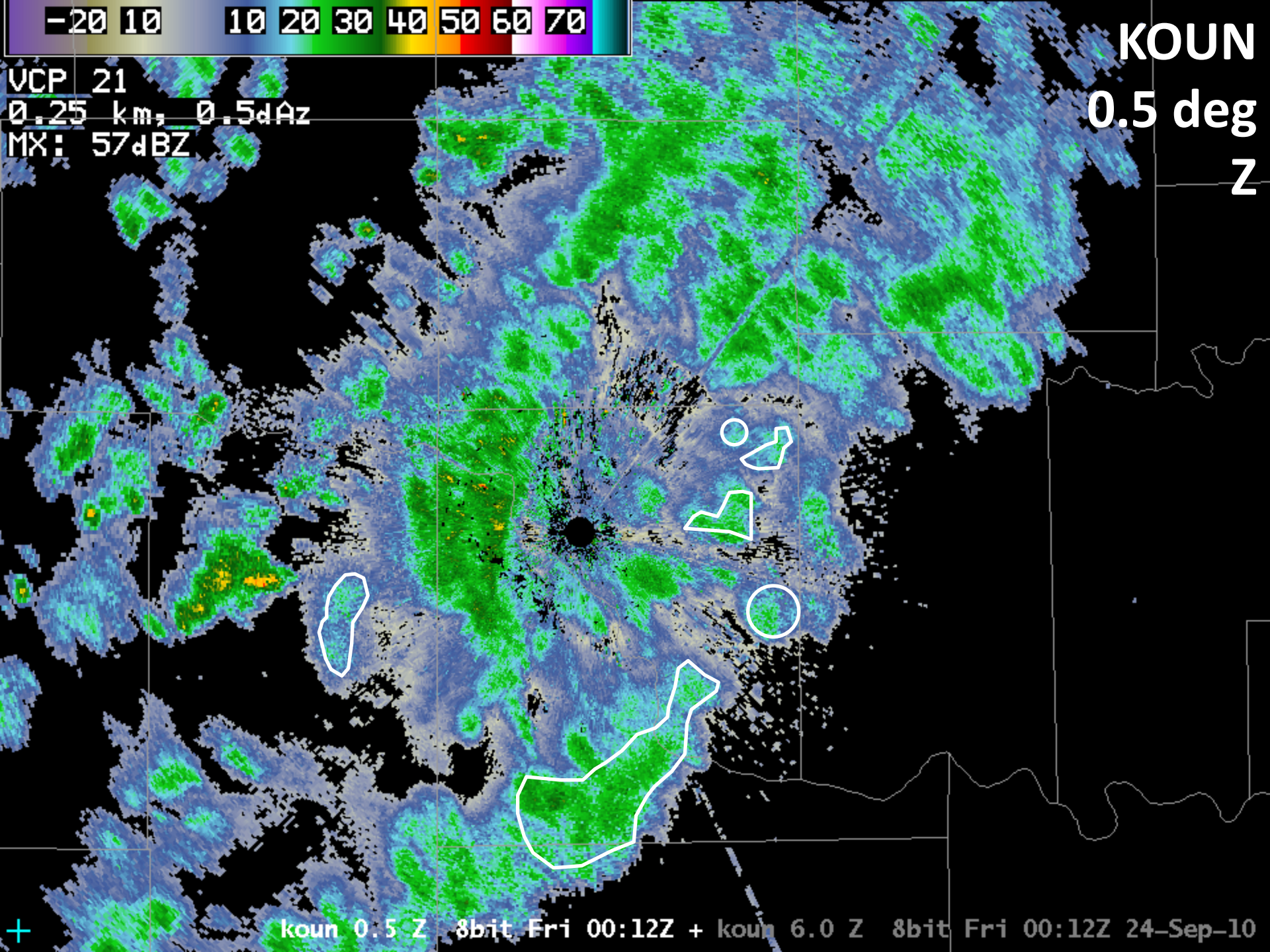

-20 10 10 20 30 40 50 60 70
VCP 21
0.25 km, 0.5dAz
MX: 44dBZ
KOUN
6.0 deg
Z
koun 0.5 Z 8bit Fri 00:12Z + koun 6.0 Z 8bit Fri 00:12Z 24-Sep-10

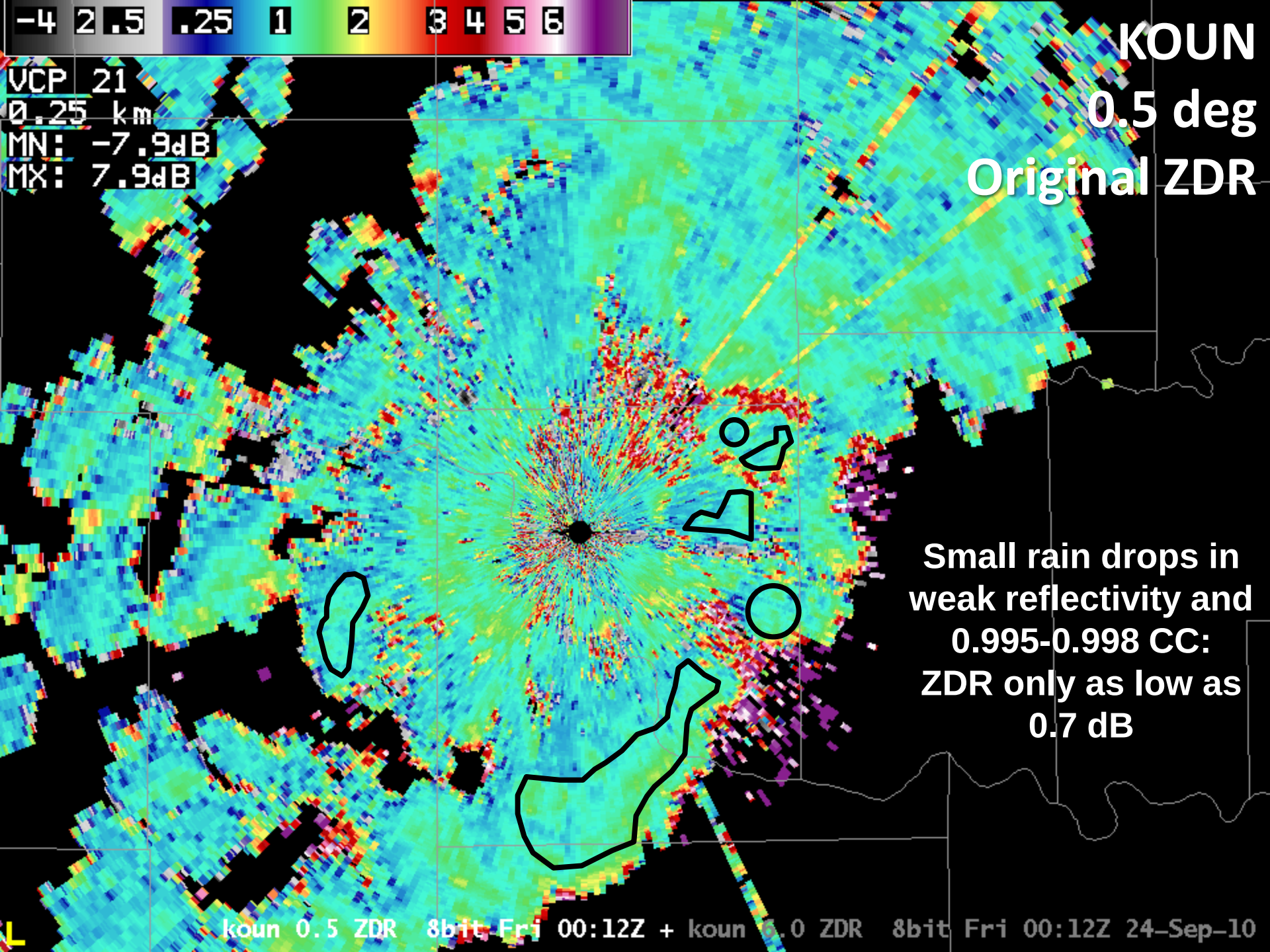

-4 .2 .65 .85 .93 .96 .98 1
VCP 21
0.25 km
MN: 0.252
MX: 1.264
KOUN
6.0 deg
CC
koun 0.5 CC 8bit Fri 00:12Z + koun 6.0 CC 8bit Fri 00:12Z 24-Sep-10

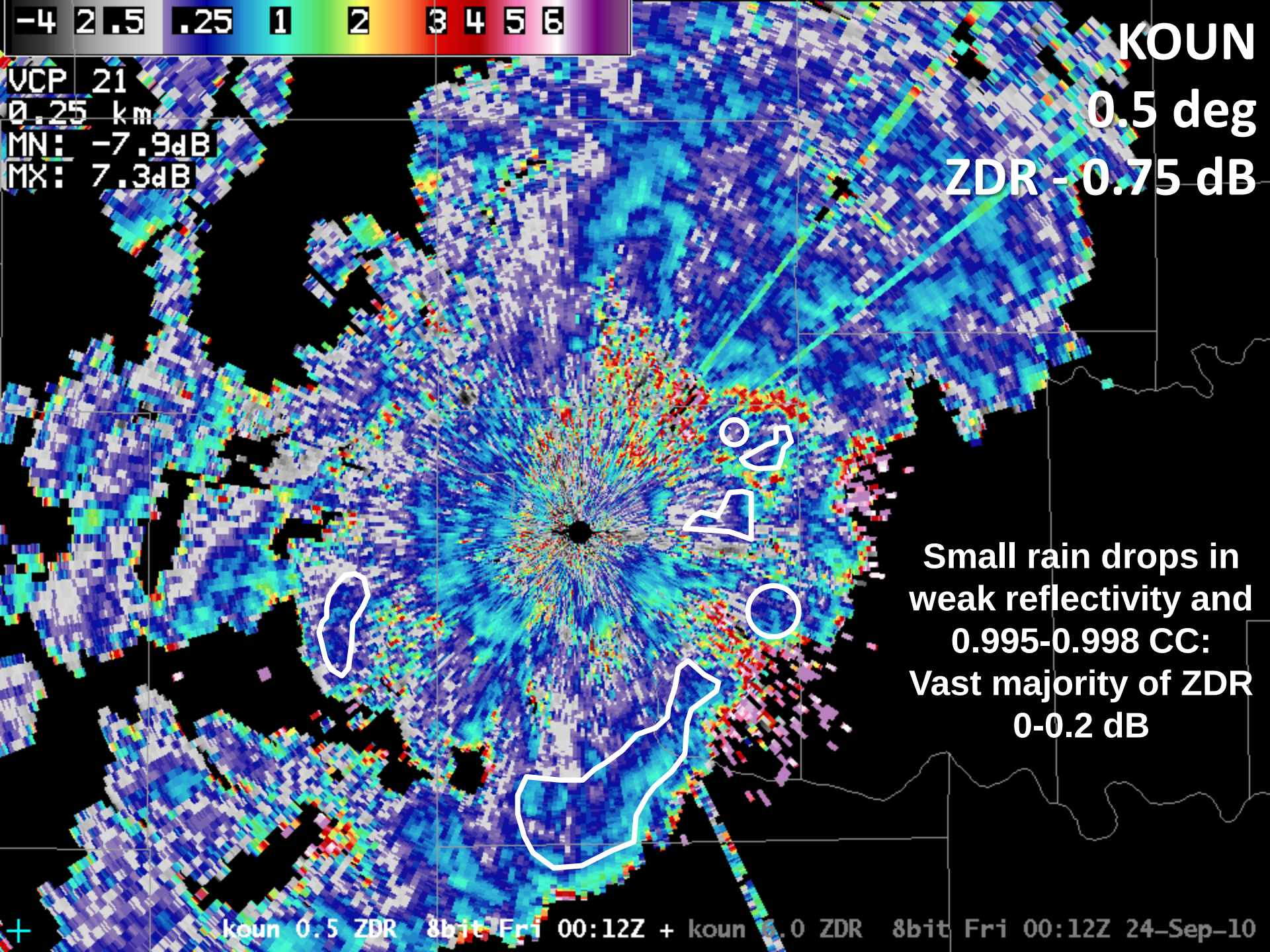

-4 2 .5 .25 1 2 3 4 5 6
VCP 21
0.25 km
MN: -7.9dB
MX: 7.9dB
Dry Snow Values range from 0.7 – 1.1dB
KOUN
6.0 deg
Original ZDR
koun 0.5 ZDR 8bit Fri 00:12Z + koun 6.0 ZDR 8bit Fri 00:12Z 24-Sep-10


-4 2 .5 .25 1 2 3 4 5 6
VCP 21
0.25 km
MN: -7.9dB
MX: 7.2dB
Vast majority of Dry Snow Values right around 0.2 dB
KOUN
6.0 deg
ZDR – 0.75 dB
koun 0.5 ZDR 8bit Fri 00:12Z + koun 6.0 ZDR 8bit Fri 00:12Z 24-Sep-10


-4 .2 .65 .85 .93 .96 .98 1
VCP 21
0.25 km
MN: 0.252
MX: 1.264
KOUN
0.5 deg
CC
koun 0.5 CC 8bit Fri 00:12Z + koun 6.0 CC 8bit Fri 00:12Z 24-Sep-10

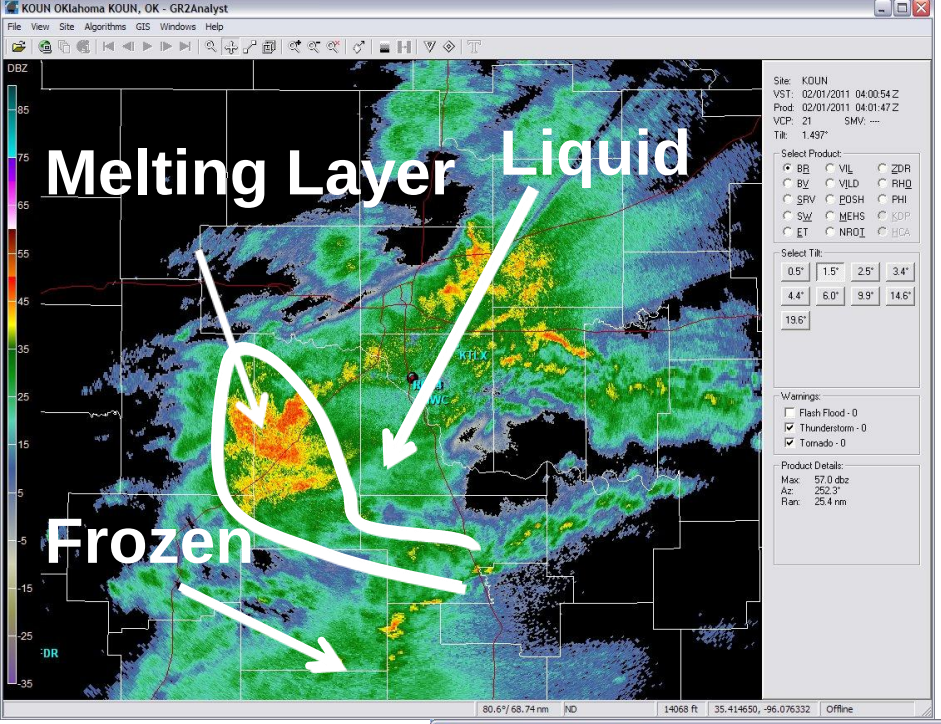

-20 10 10 20 30 40 50 60 70
VCP 21
0.25 km, 0.5dAz
MX: 57dBZ
KOUN
0.5 deg
Z
koun 0.5 Z 8bit Fri 00:12Z + koun 6.0 Z 8bit Fri 00:12Z 24-Sep-10

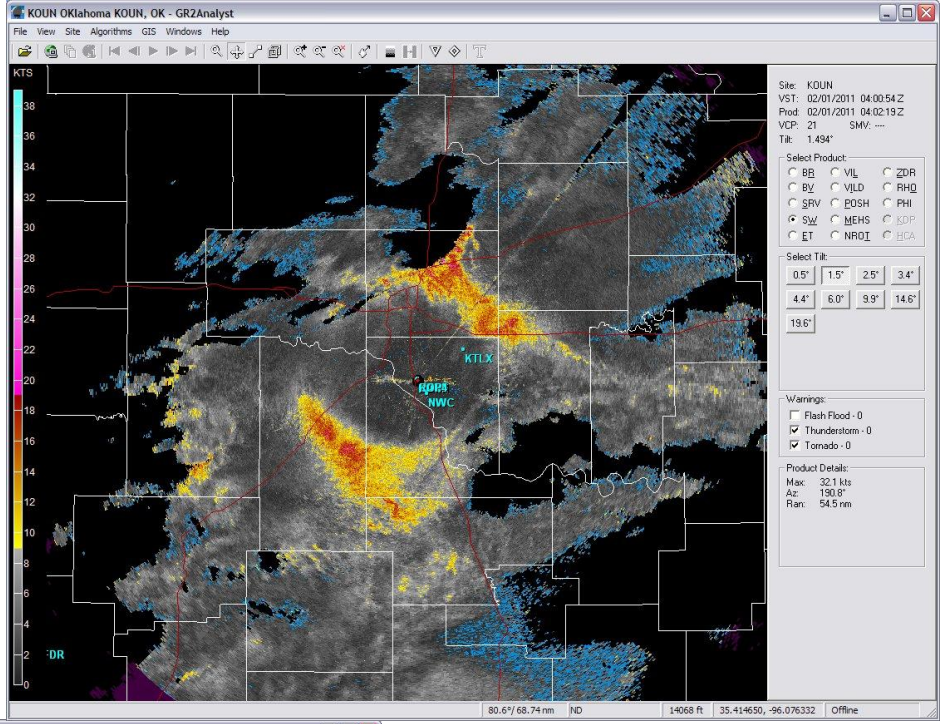

-4 2 .5 .25 1 2 3 4 5 6
VCP 21
0.25 km
MN: -7.9dB
MX: 7.9dB
KOUN
0.5 deg
Original ZDR
Small rain drops in weak reflectivity and 0.995-0.998 CC: ZDR only as low as 0.7 dB
koun 0.5 ZDR 8bit Fri 00:12Z + koun 6.0 ZDR 8bit Fri 00:12Z 24-Sep-10

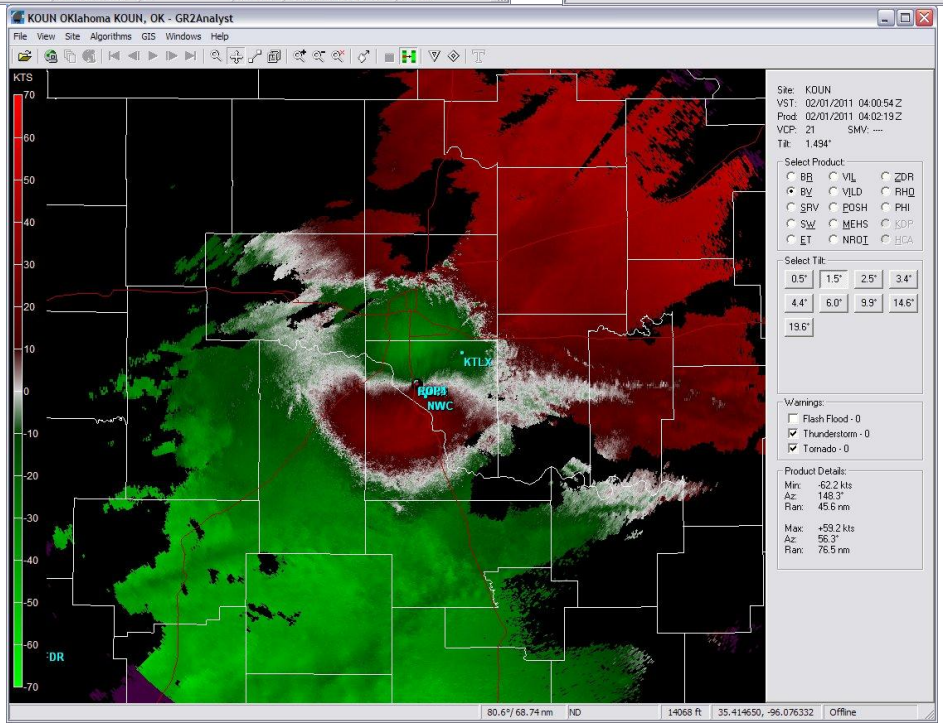

-4 2 .5 .25 1 2 3 4 5 6
VCP 21
0.25 km
MN: -7.9dB
MX: 7.3dB
KOUN
0.5 deg
ZDR - 0.75 dB
Small rain drops in weak reflectivity and 0.995-0.998 CC: Vast majority of ZDR 0-0.2 dB
koun 0.5 ZDR 8bit Fri 00:12Z + koun 0.0 ZDR 8bit Fri 00:12Z 24-Sep-10

Remaining ZDR Calibration Issue

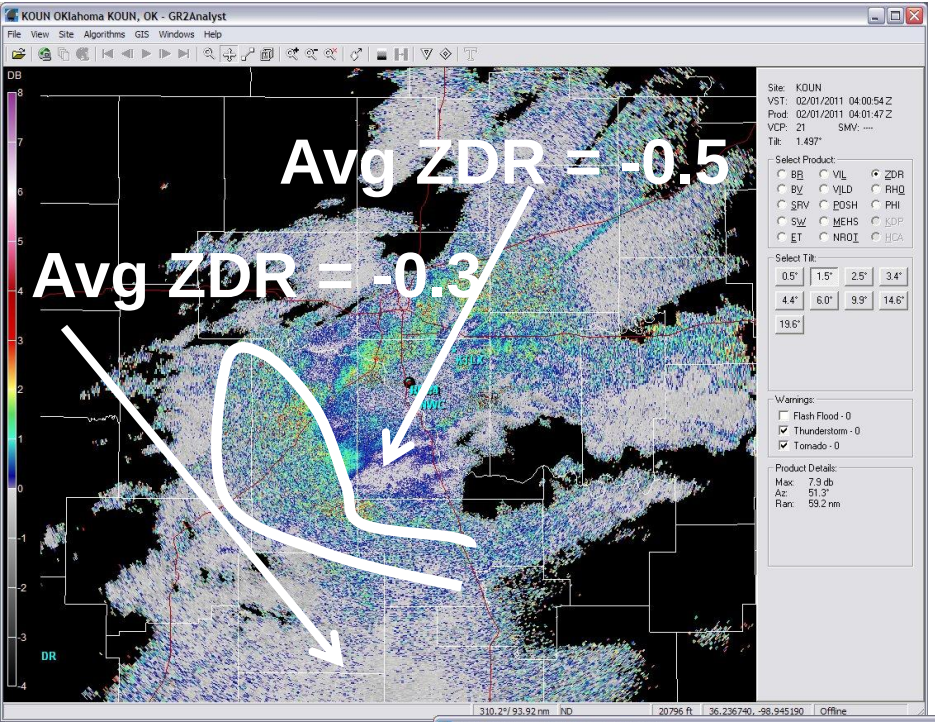
- Subjective human analysis ZDR evaluation
  - 2/1/11
    - 0400 UTC
    - VCP 21
  - 2/4/11
    - 1535 UTC
    - VCP 21
  - Bypass Map Clutter Filtering
  - Stratiform snow events



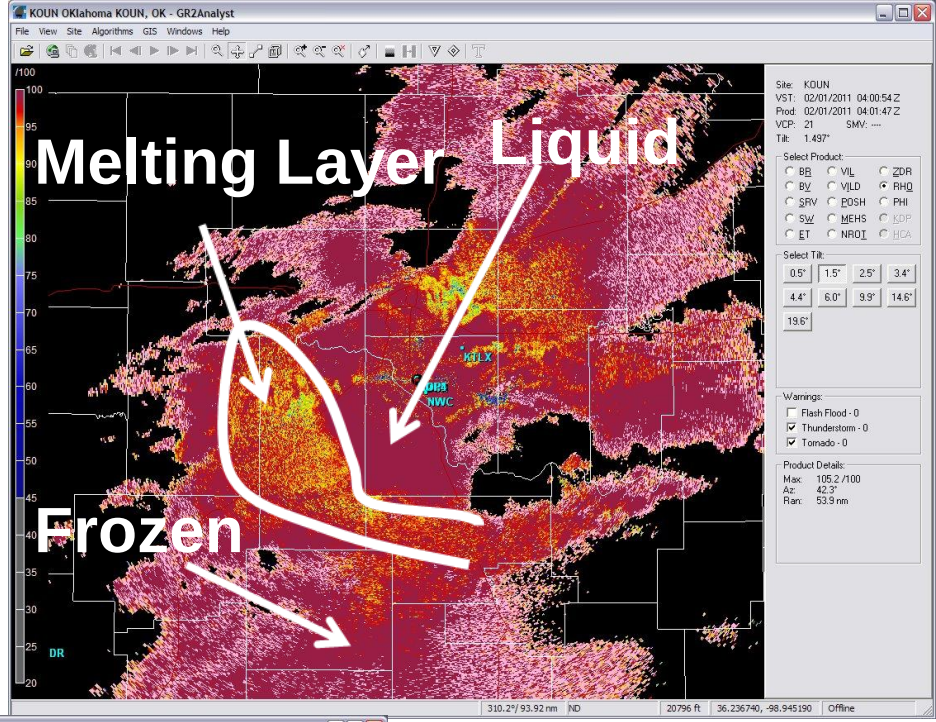




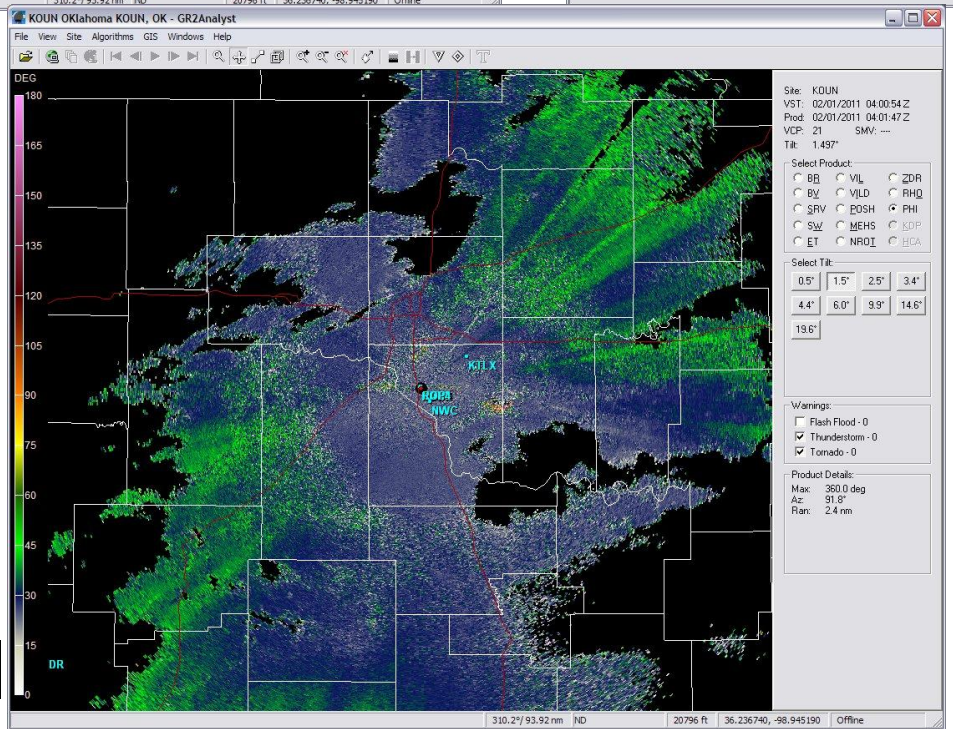
KOUN
0400Z
VCP 21
01Feb11



ZDR

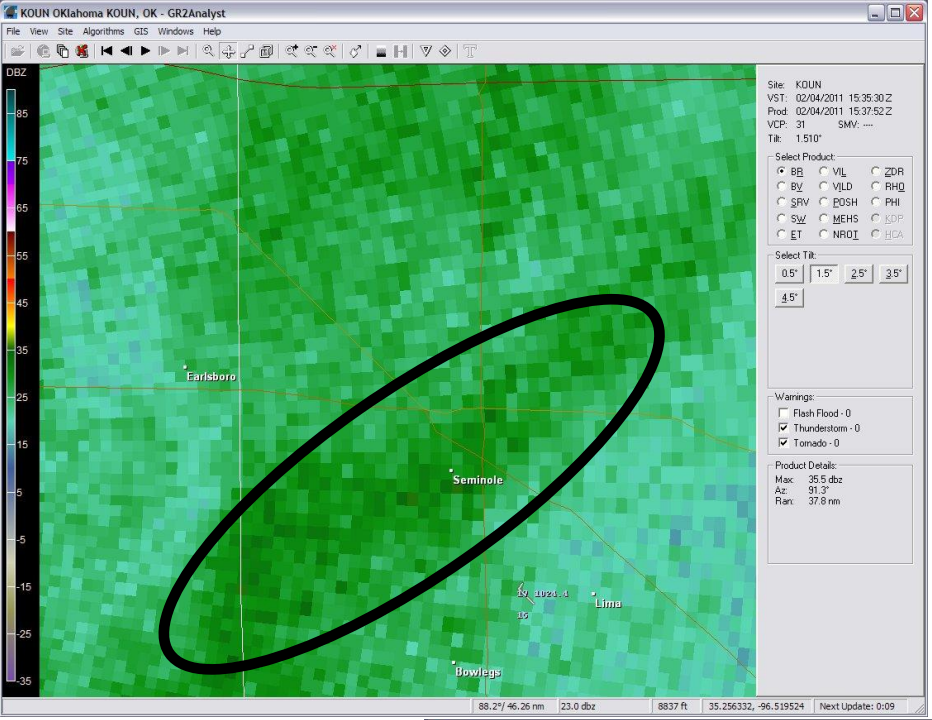


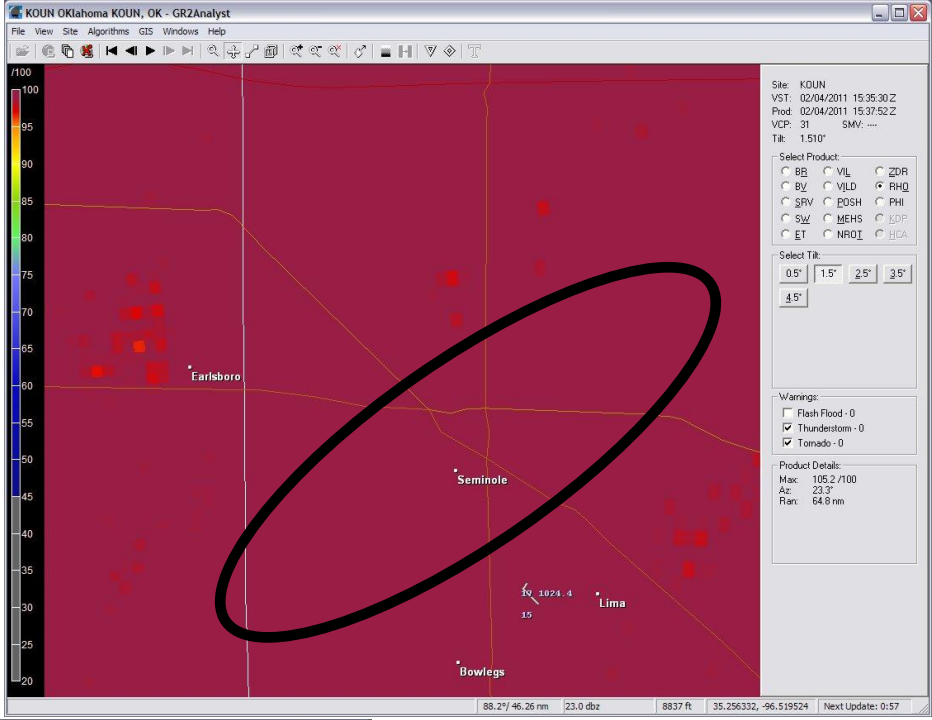
CC

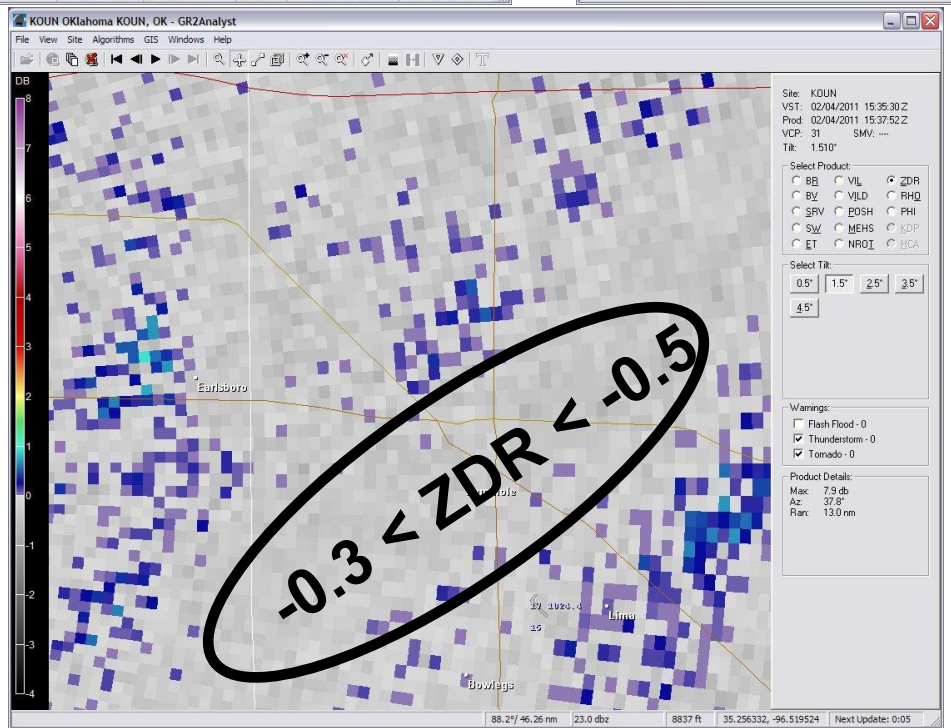


PHI

KOUN
0400Z
VCP 21
01Feb11







KOUN
1535Z
VCP 31
04Feb11

ZDR Evaluation Summary

- 9/23/10 Light Stratiform Rain
  - 3 experts examined the data independently and came up with “0.7 to 0.8 dB too high” for bias
- Hardware and software fixes occurred in January 2011
- February 2011Snow Storms
  - All events showed ZDR too low by ~0.5 dBz.

Summary

- Dual-Pol Improved Capability
  - Forecasters can use new DP variables to provide enhanced information and new capabilities
- Resolved Issues
  - System sensitivity, reflectivity calibration, DP base variable computation and display, and algorithm software bugs and refinement issues
- Remaining Issues
  - Algorithm refinement
  - ZDR calibration not sufficient for QPE algorithm to properly provide enhanced performance over Legacy algorithms

Questions?