CSWR Data Summary and Overview

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Surprise!

There were 4 VORTEX2 tornadoes that can be confirmed by DOWs.

VORTEX2 Tornado Verification by DOWs: Criteria: (>40 m/s DV) / (< 2 km)

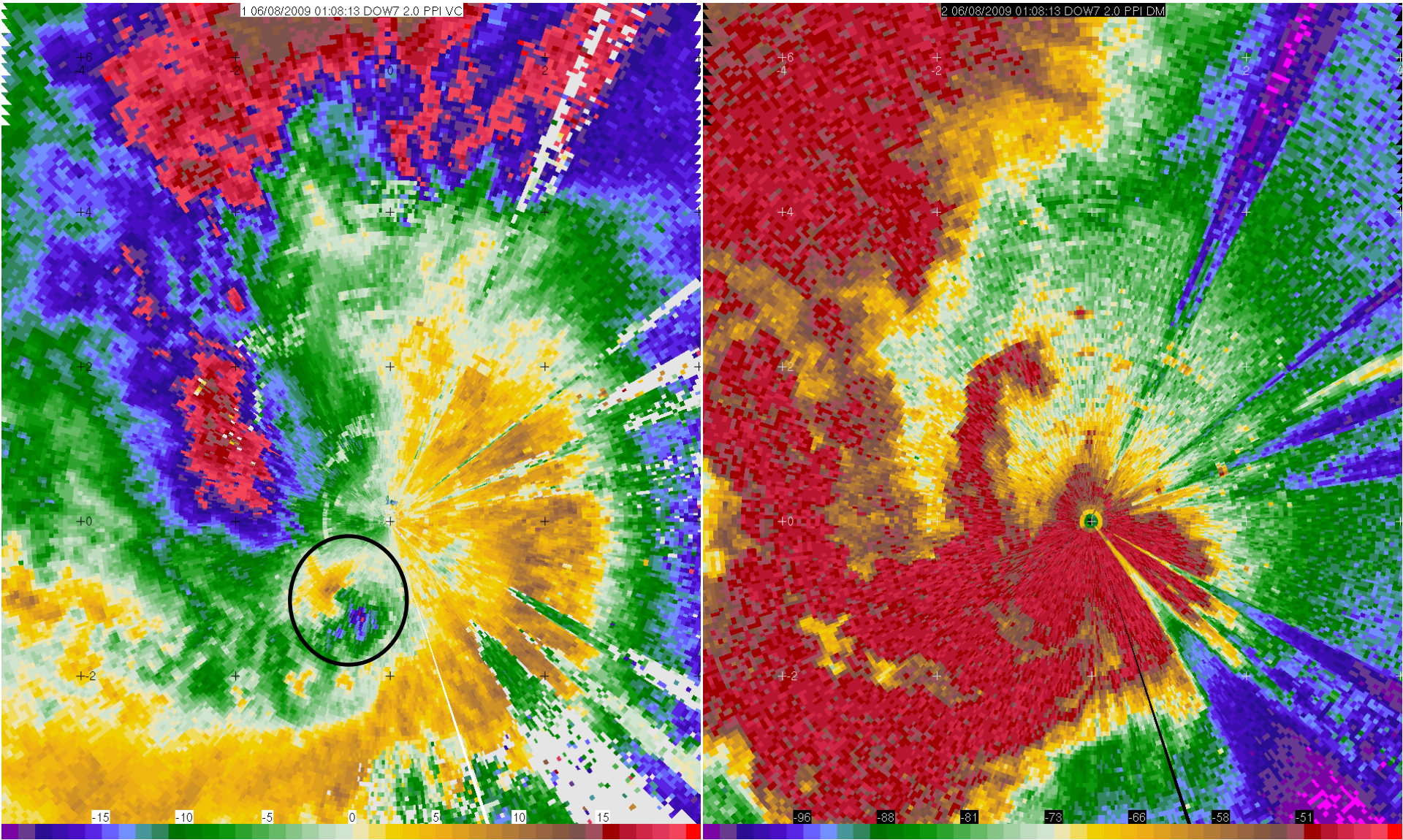
Stormdata lists several tornadoes which VORTEX2 was near.

Stormdata courtesy of Don Burgess and Kiel Ortega

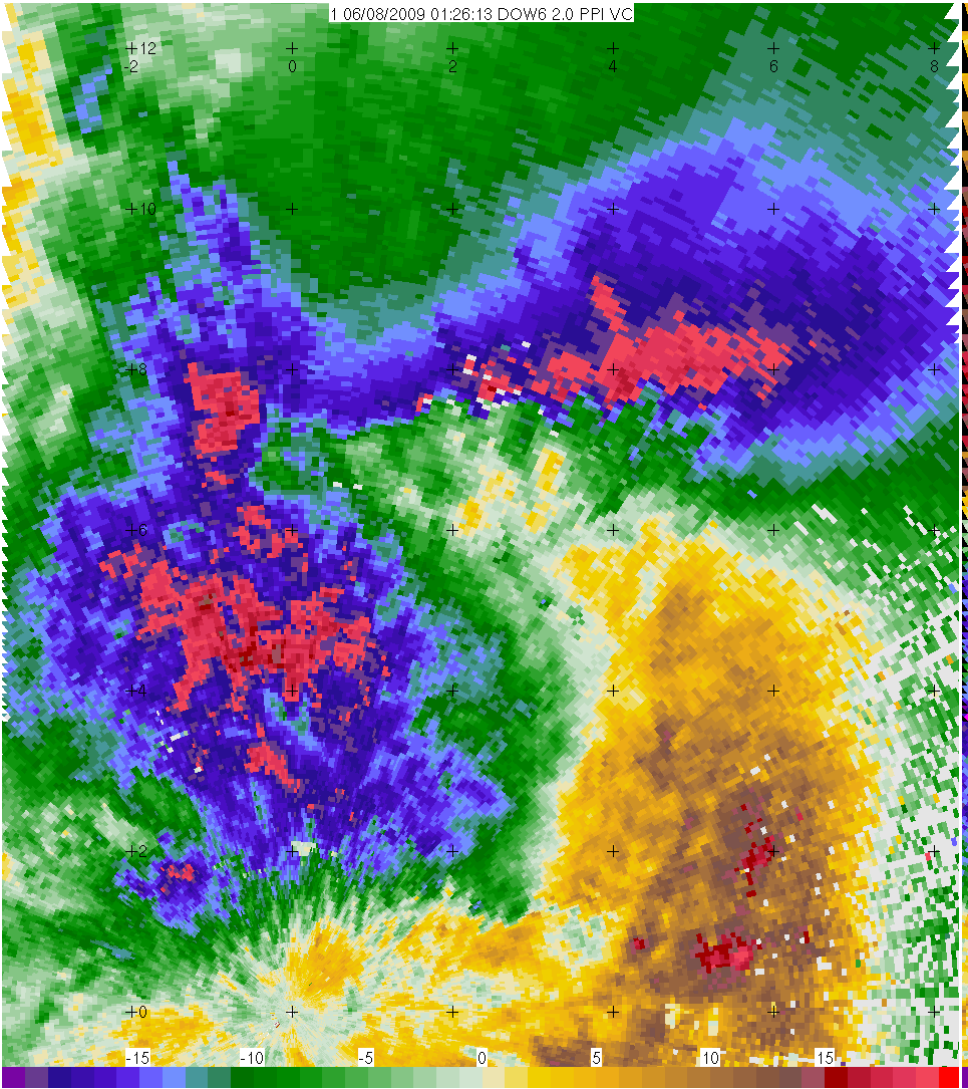
Tornadoes during V209 Operations (from Storm Data)

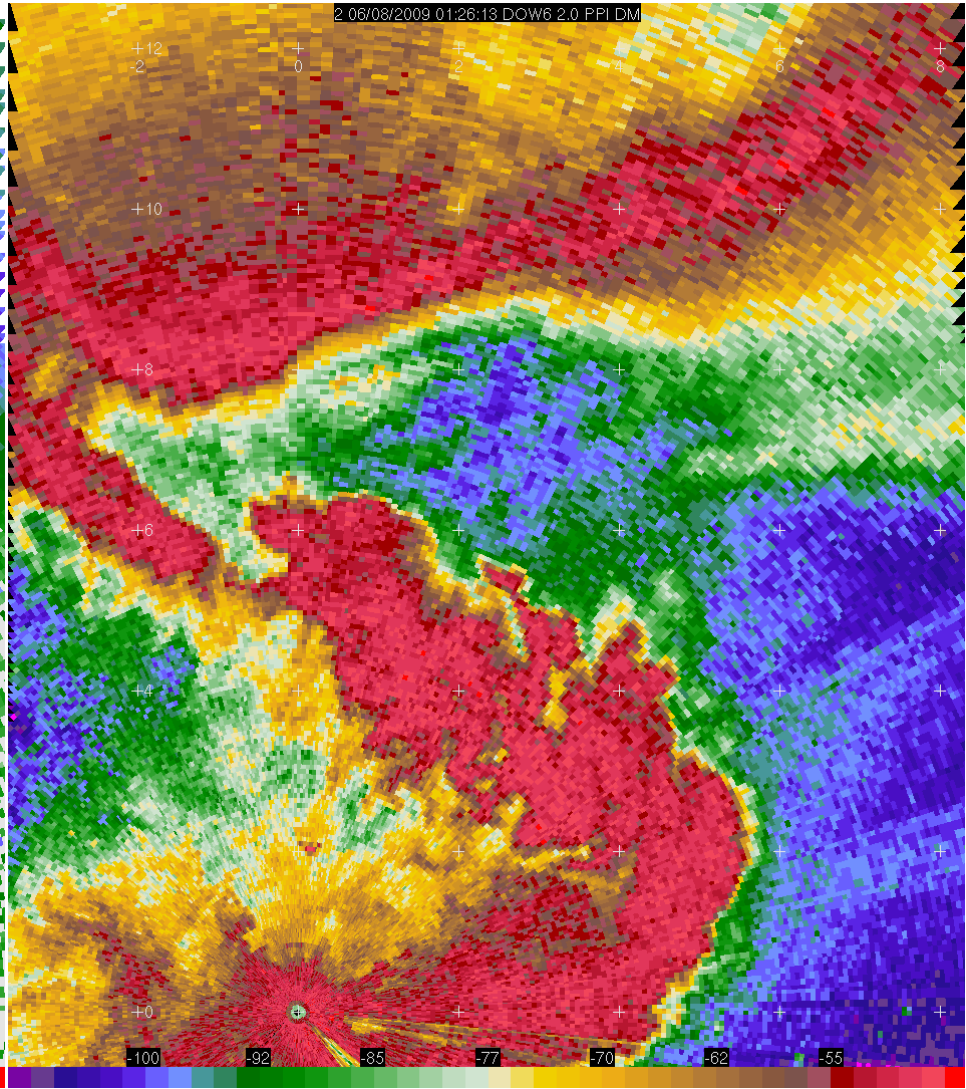
				Date	StartLat	StartLon	EndLat	EndLon	Start Time	End Time	Comment
1	**Confirmed**	Bear Creek		5-Jun	41.63	-104.383	41.6134	-104.224	2207	2231	Goshen County Tornado
	Can't Confirm	Albin	DOW too far away: 23 km	5-Jun	41.4891	-103.947	41.4891	-103.947	2349	2350	2nd Tornado from Goshen Co. Storm; in Nebraska
2	**Marginal**	Amity	41 m/s delta-V over 300 m	8-Jun	39.87	-94.43	39.87	-94.43	0113	0114	NW Missouri Storm Tornado #1
	No	Weatherby	Broad, ~1.5-2 km 40 m/s DV	8-Jun	39.91	-94.26	39.91	-94.26	0127	0128	NW Missouri Storm Tornado #2
3	**Marginal**	Mullenville	Two marginal tornadoes:	9-Jun	37.6482	-99.4191	37.6474	-99.4086	2353	2354	Greensburg, KS Storm
4			2339-2341, 2348-2349								
	No		Circ @2352-2354 sub-tornadic @37 m/s DV								
	No DOW data		Maybe UMXP or NOXP going home	11-Jun	3776	-100.94	37.3603	-100.935	0128	0129	Sublette, KS Storm
	No			12-Jun	38.0869	-103.893	38.0805	-103.875	0003	0005	La Junta, CO Northern Storm
	Can't Confirm		DOW too far away: 28 km	12-Jun	38.2064	-103.524	38.2027	-103.503	0035	0037	La Junta, CO Southern Storm not observed by V2 (?), Confirmed by good chaser pics/video

07 June: “Tornado” passes through Amity. One limb down.

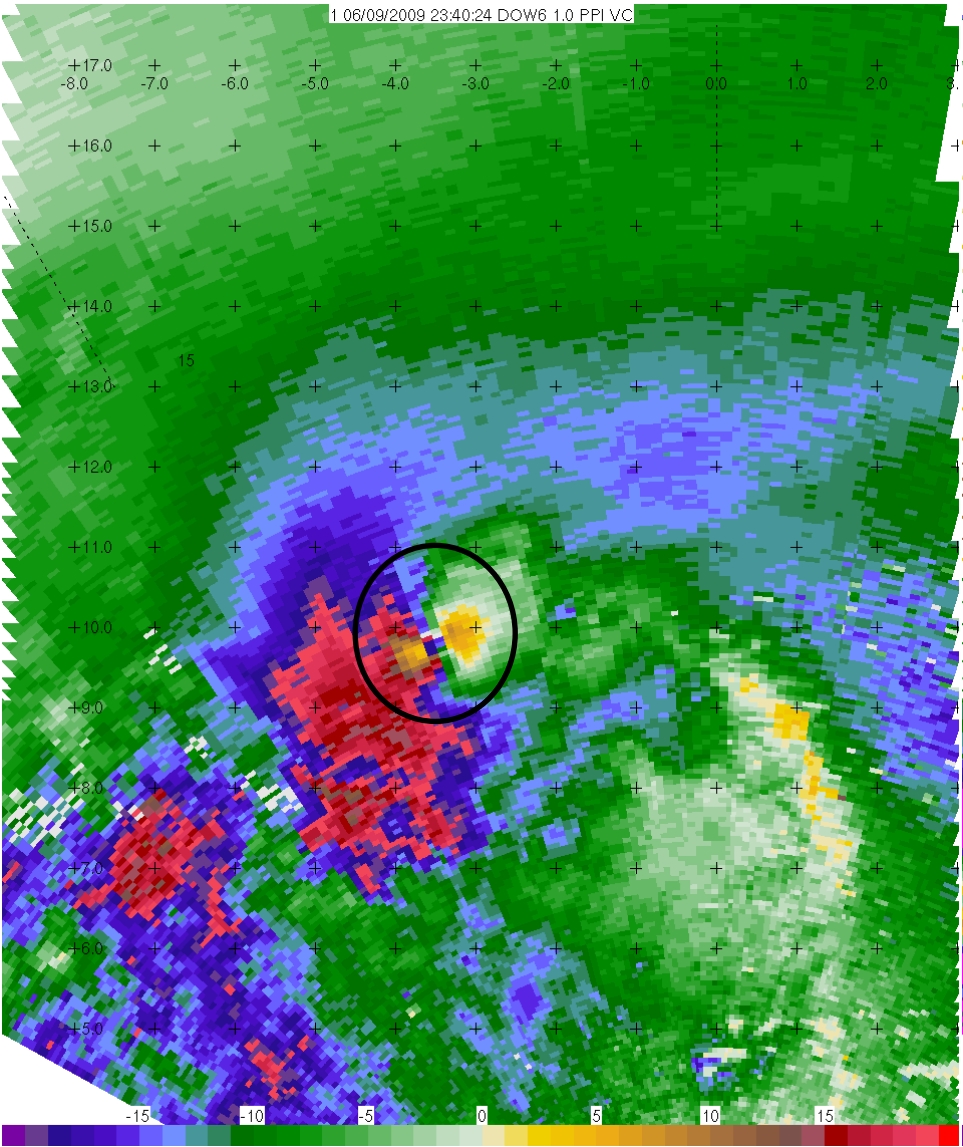


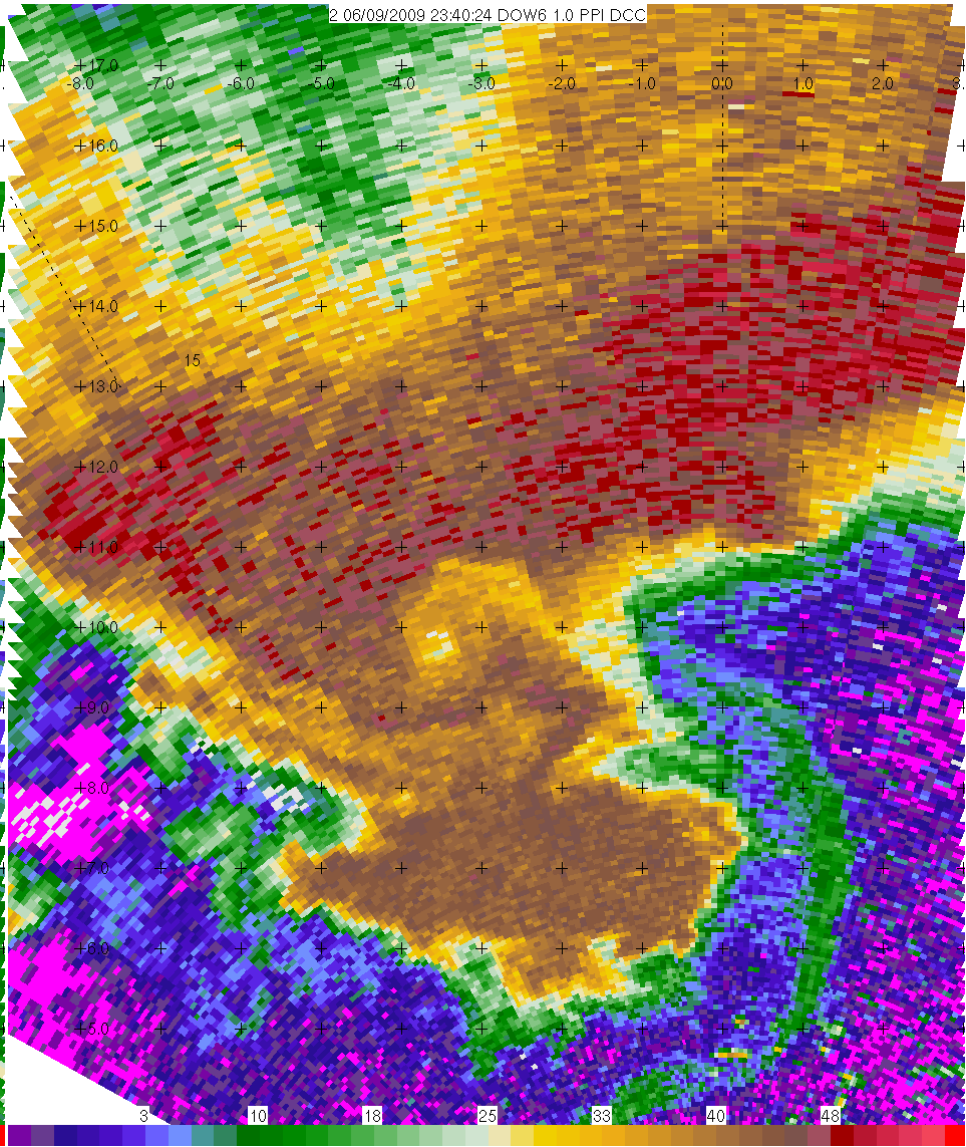
07 June: Weatherby: No Tornado



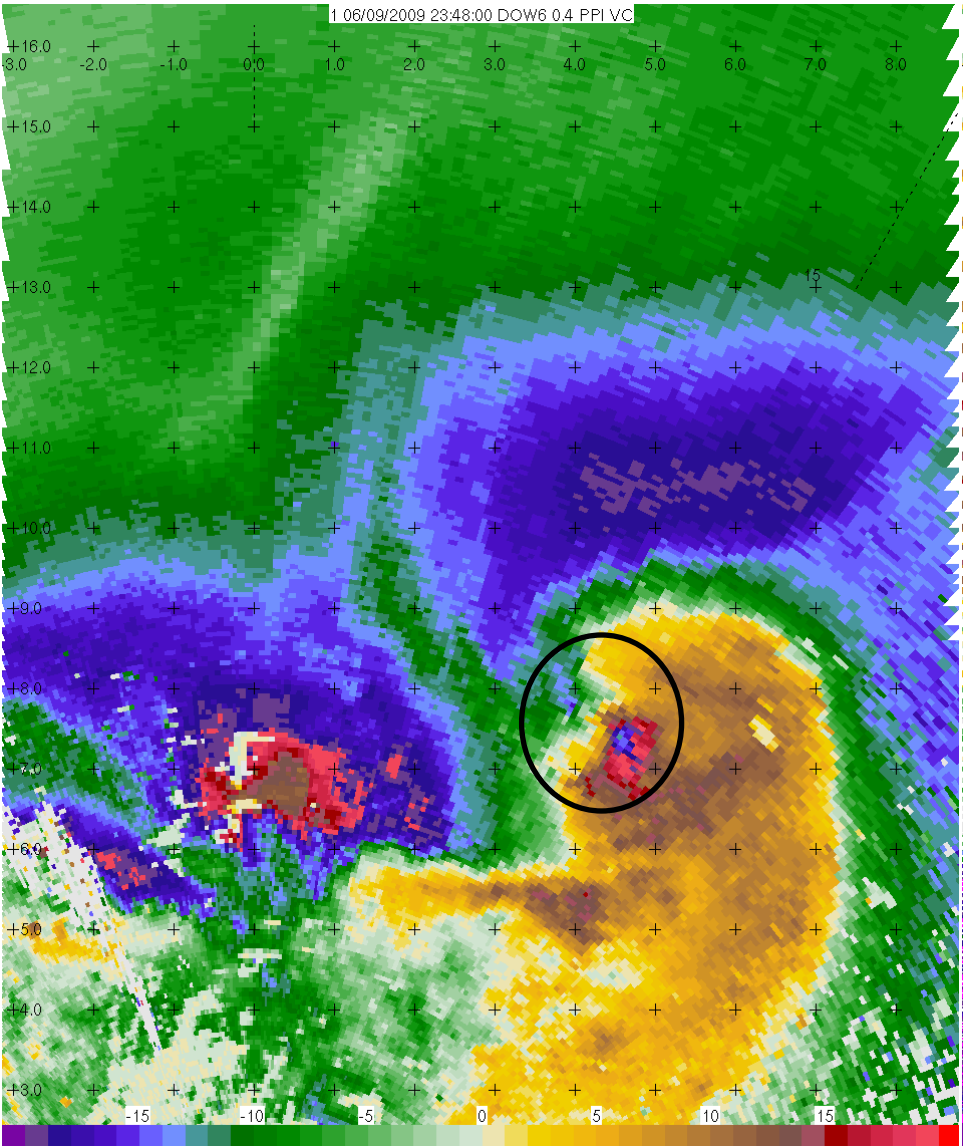


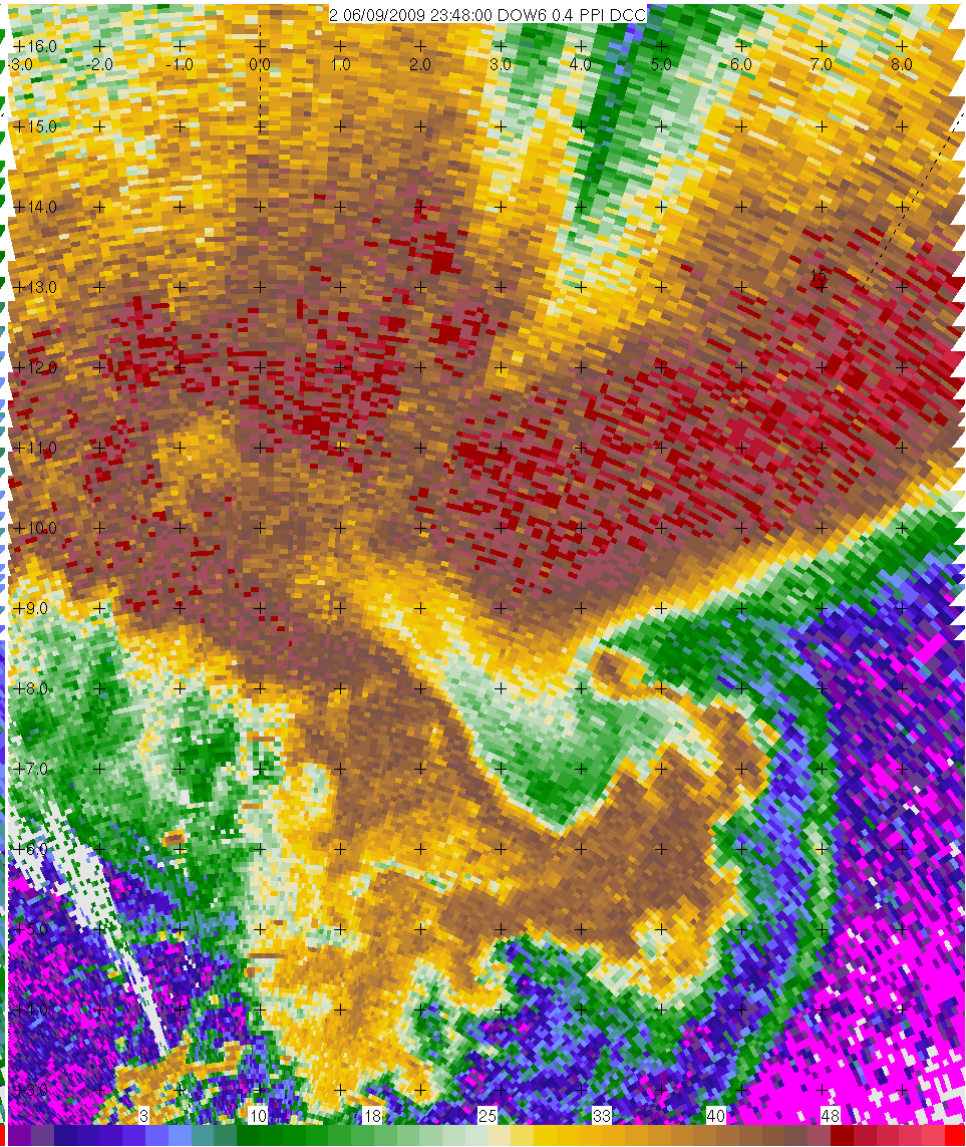
09 June: Mullenville: Tornado for 1 minute



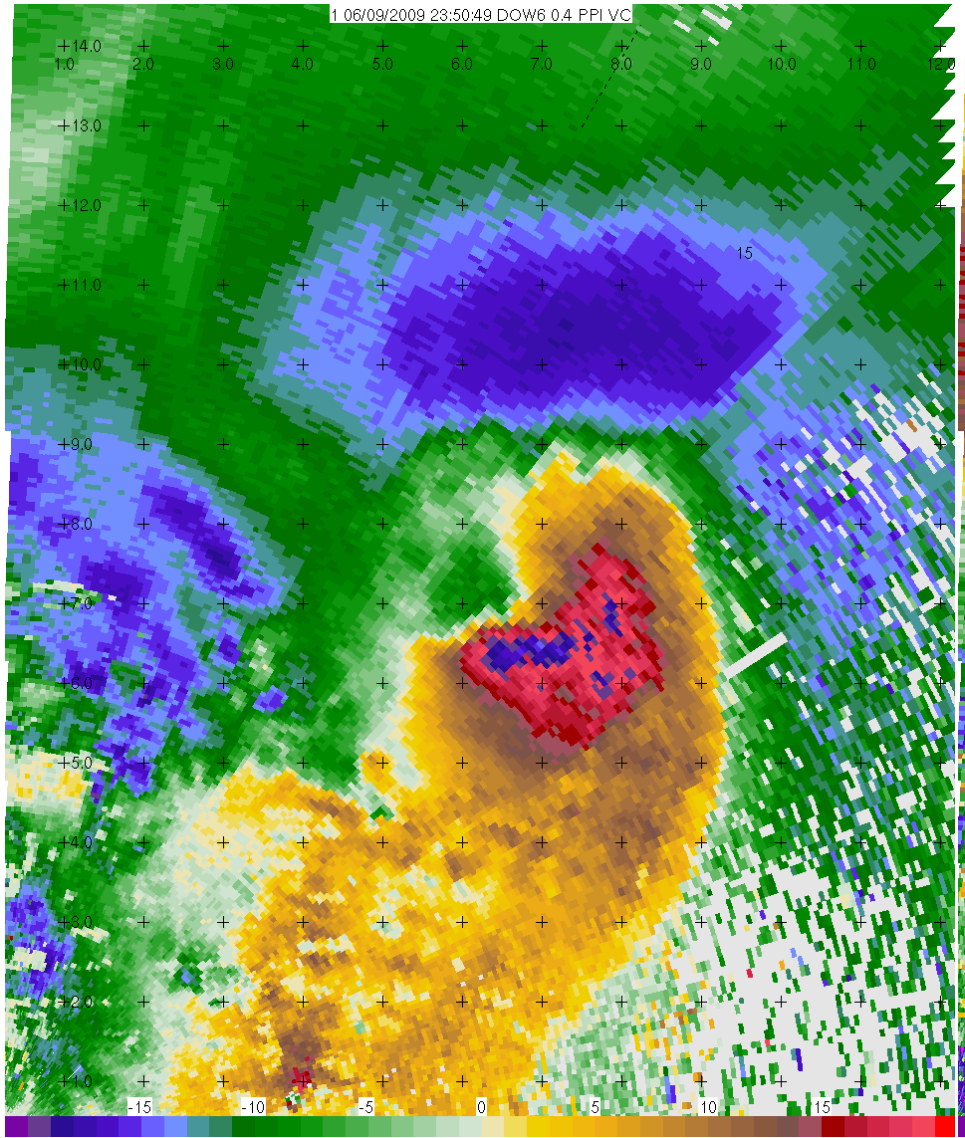


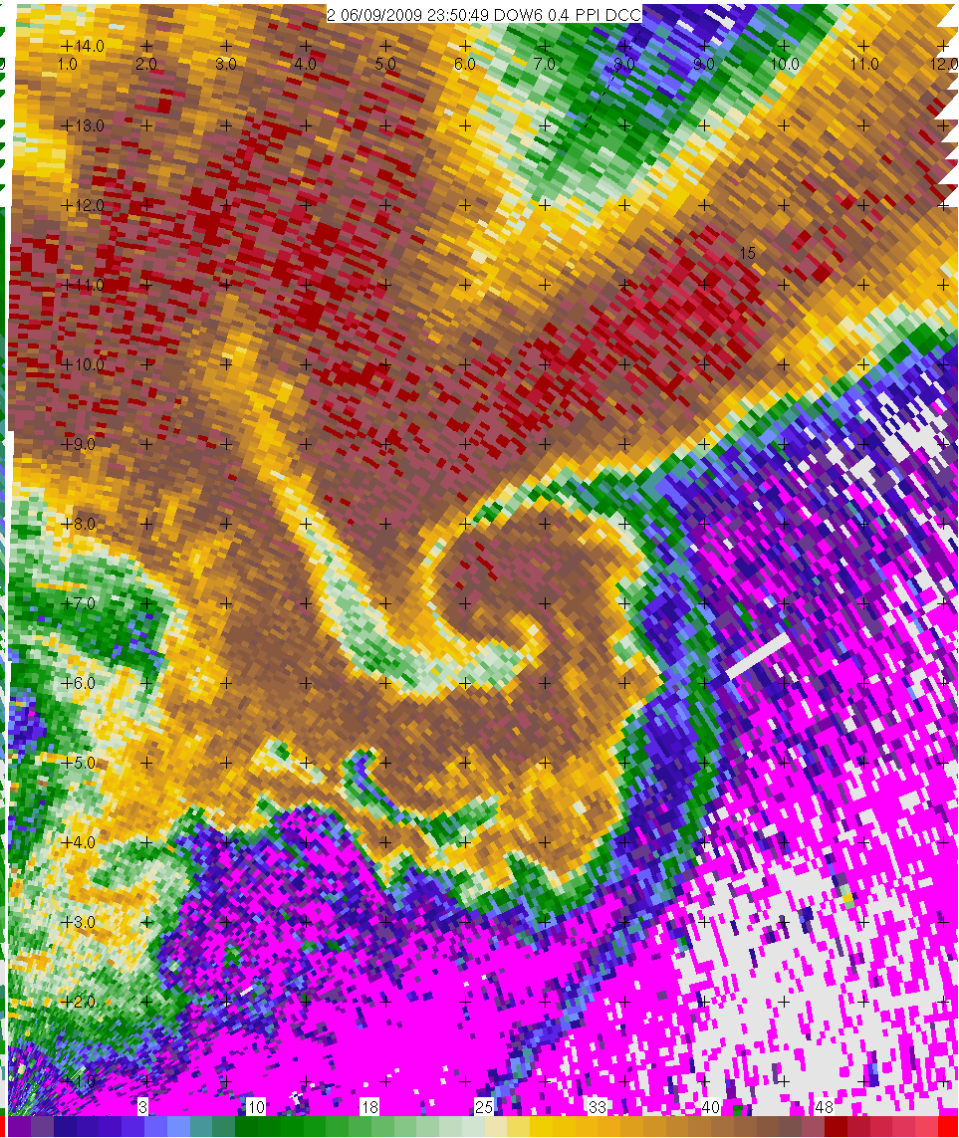
09 June: Mullenville: 2nd Tornado for 1 minute



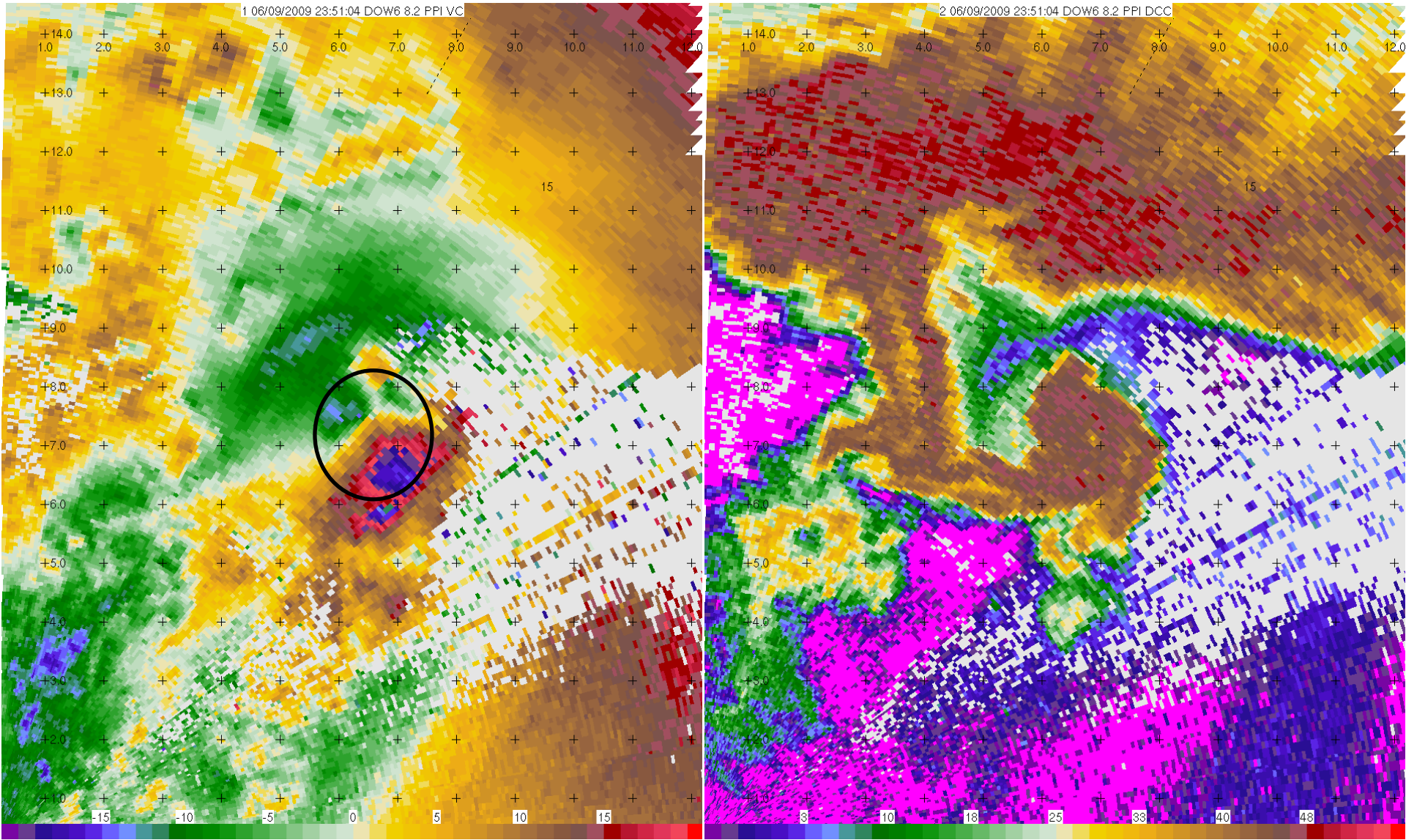


09 June: Mullenville: Not a tornado

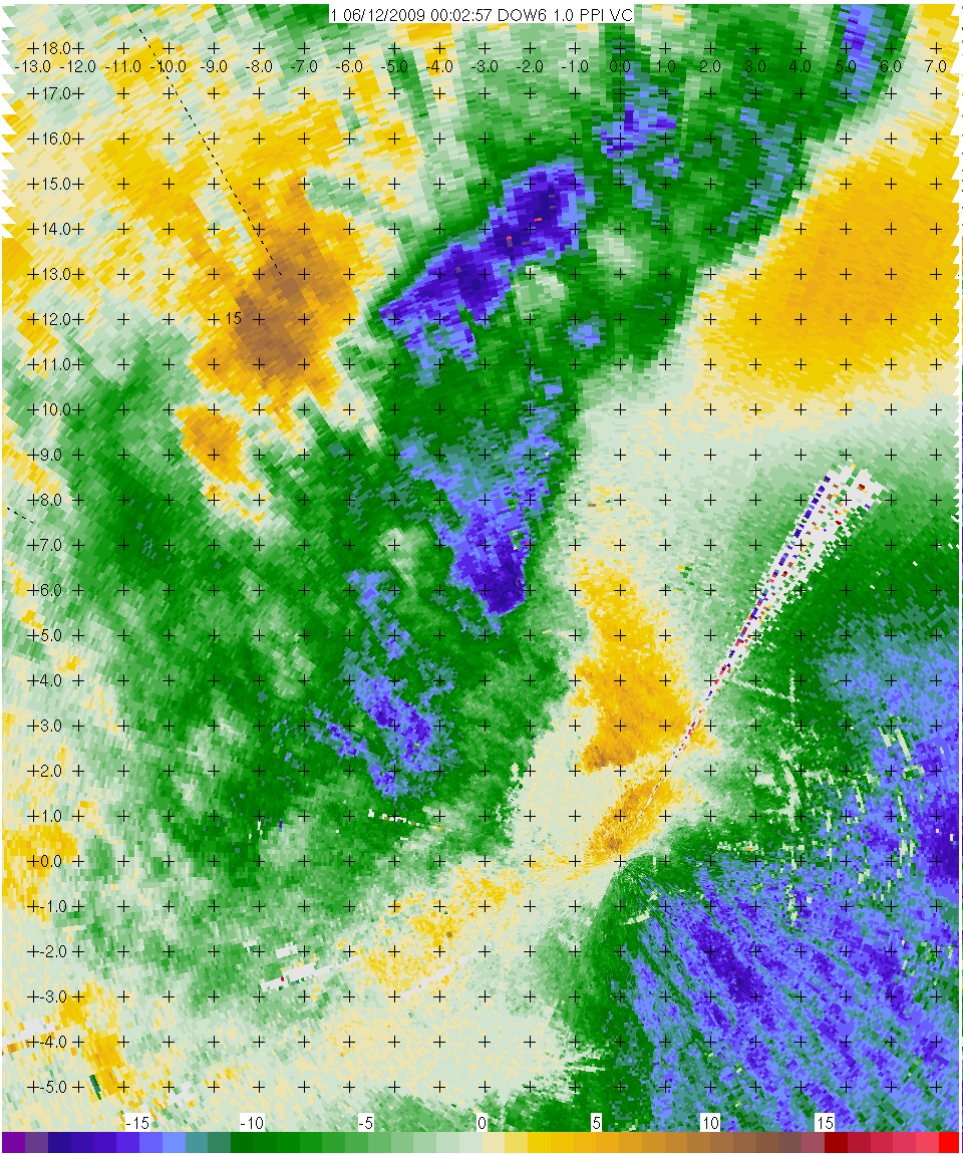


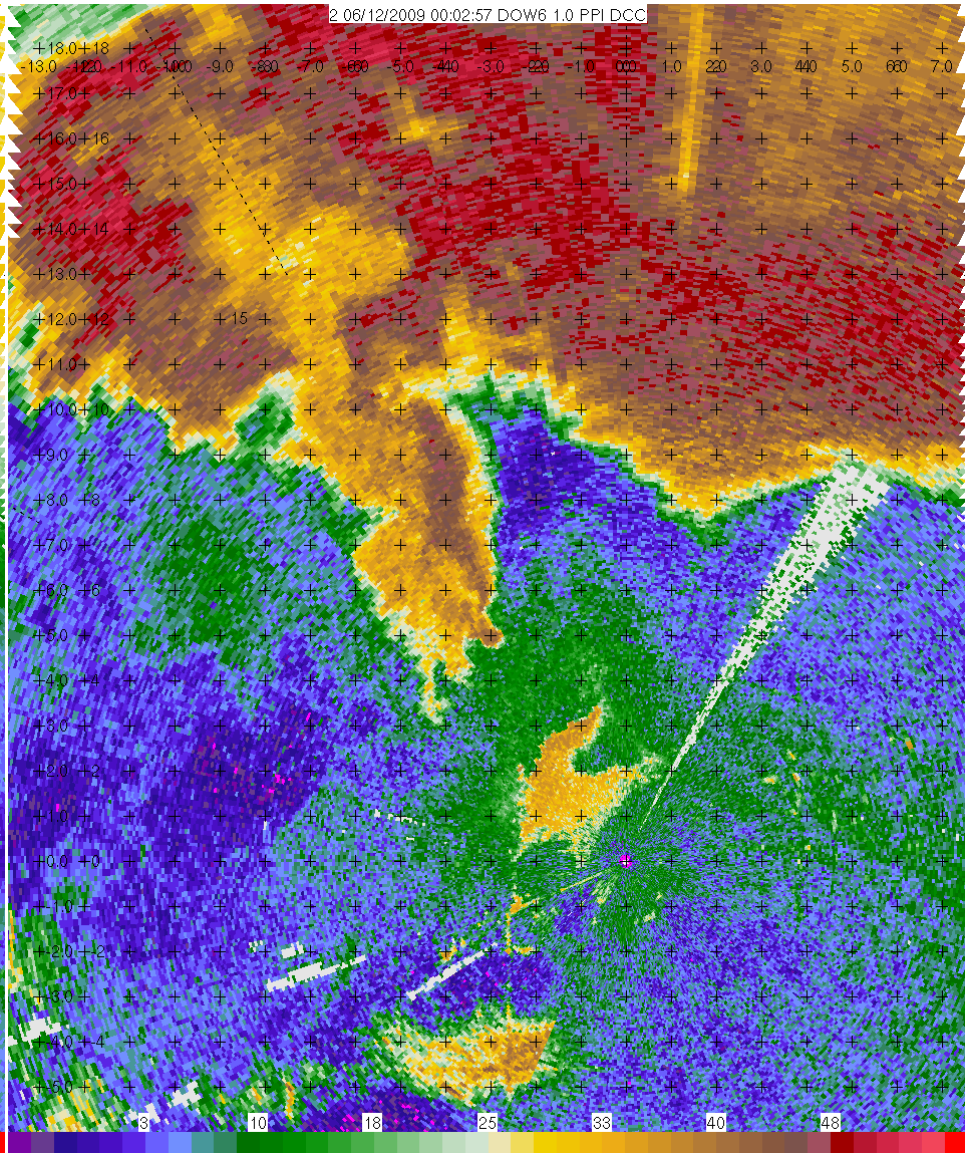


09 June: Mullenville: Not a tornado 40 m/s, but 8 degree scan. @ 10 km = ~ 1 km AGL



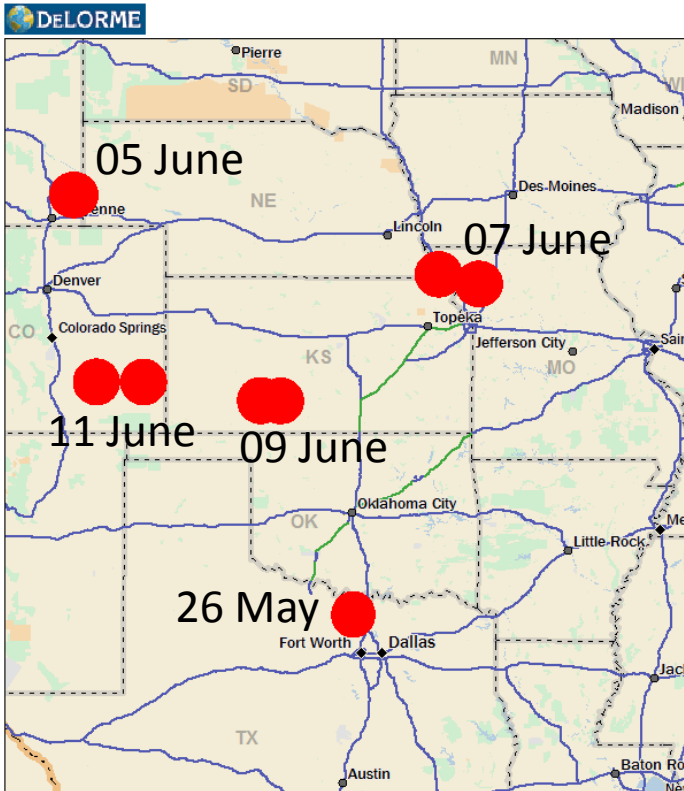
11 June: La Junta Storm: Not a tornado





High Priority Days: As conveyed to us by other PI's.

- 11 June: Hawley to Lamar Colorado
- 09 June: Ford to Greensburg, Kansas:
- 07 June: Rulo, Nebraska to Amity, Missouri:
- 05 June: Bear Creek to Albin, Wyoming: The Bear Creek / Morrie Ranch Tornado

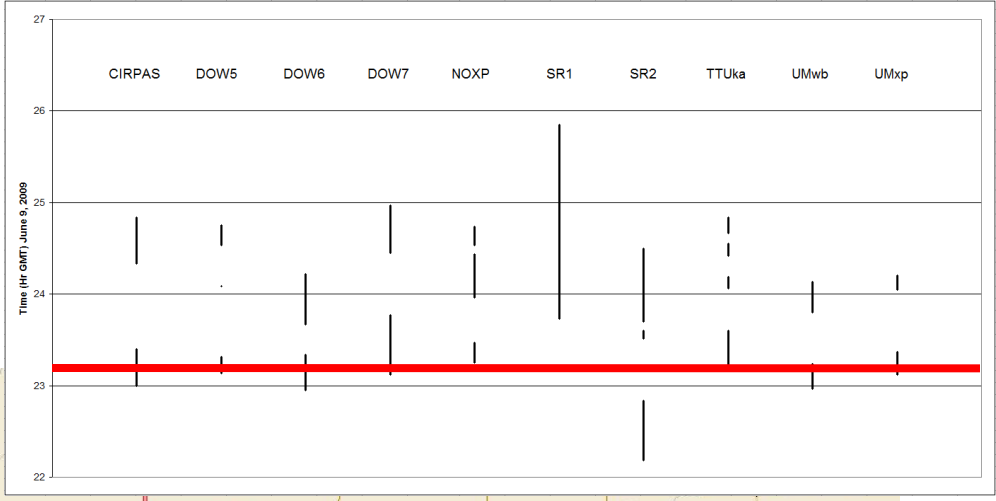


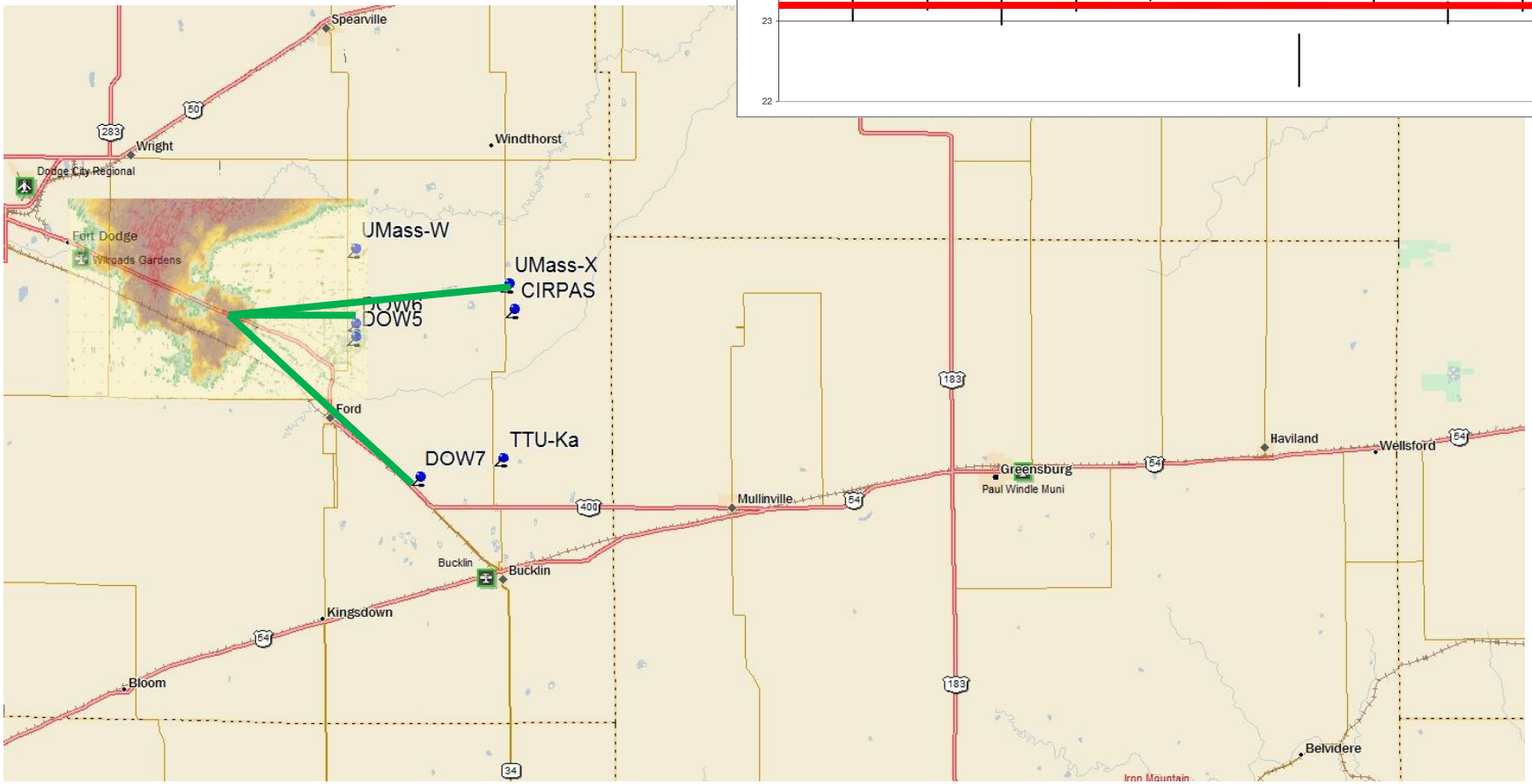
09 June

09 June 2009: Ford to Greensburg, Kansas

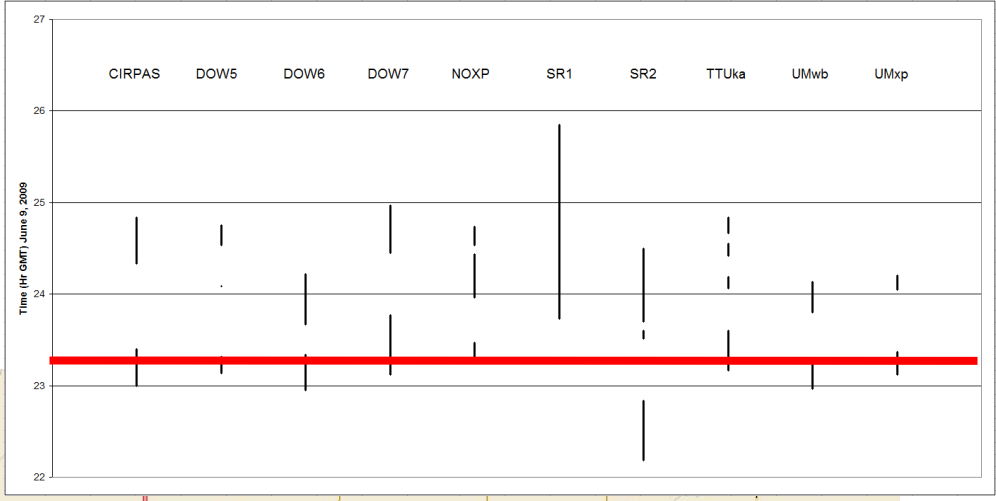
2310

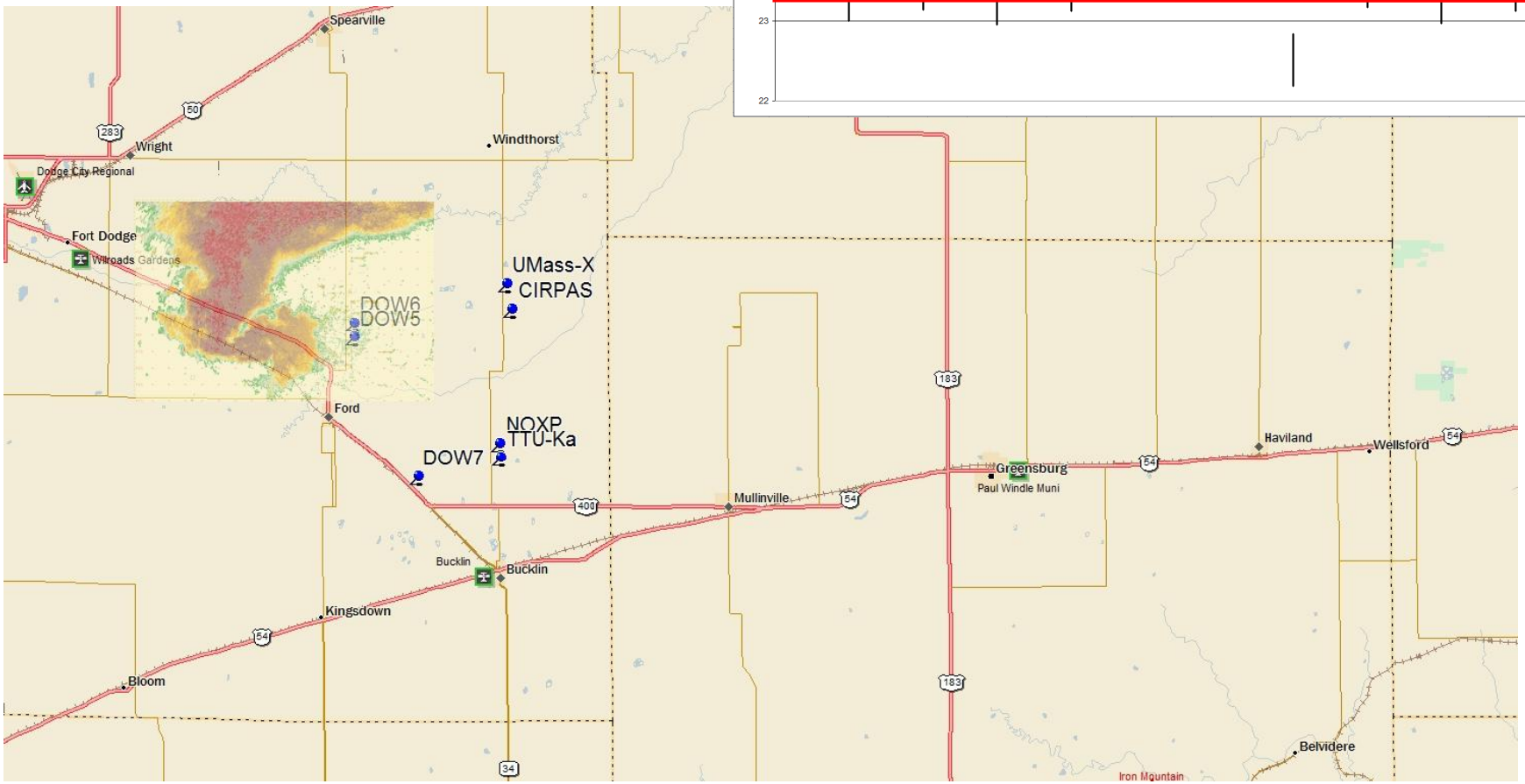
Swarm of radars at mesocyclone scale



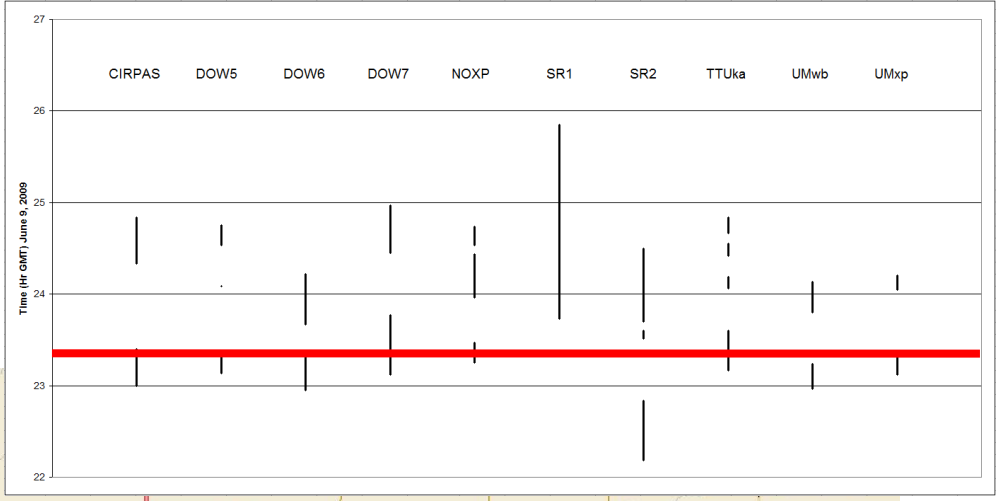


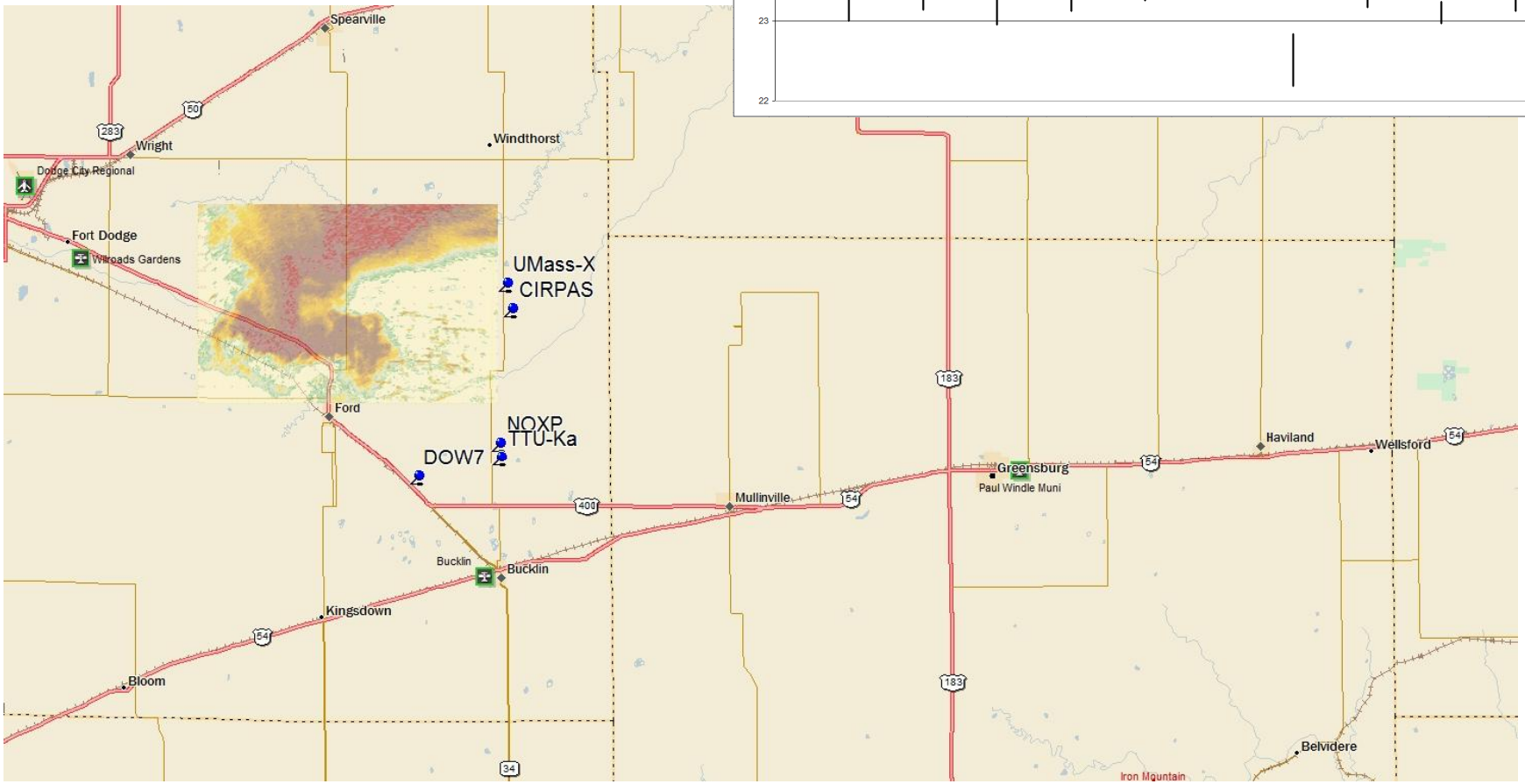
09 June 2009: Ford to Greensburg, Kansas





09 June 2009: Ford to Greensburg, Kansas

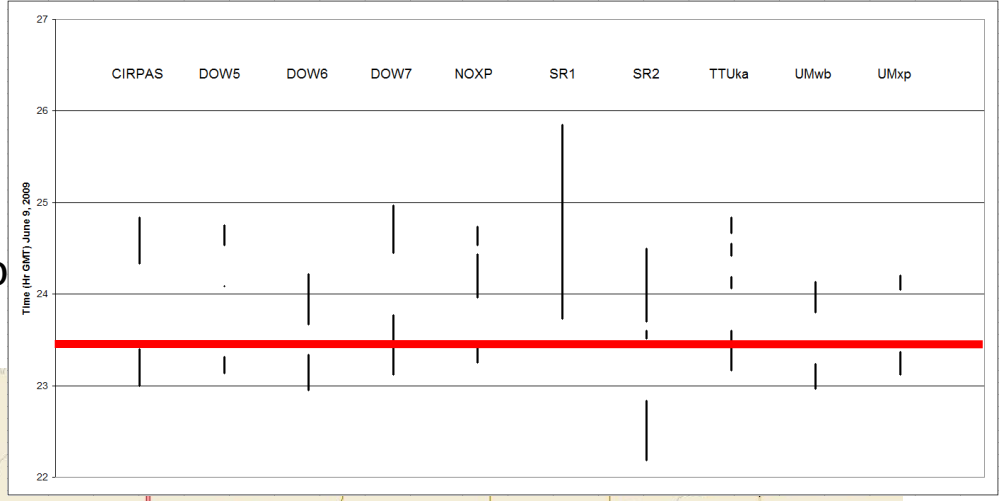


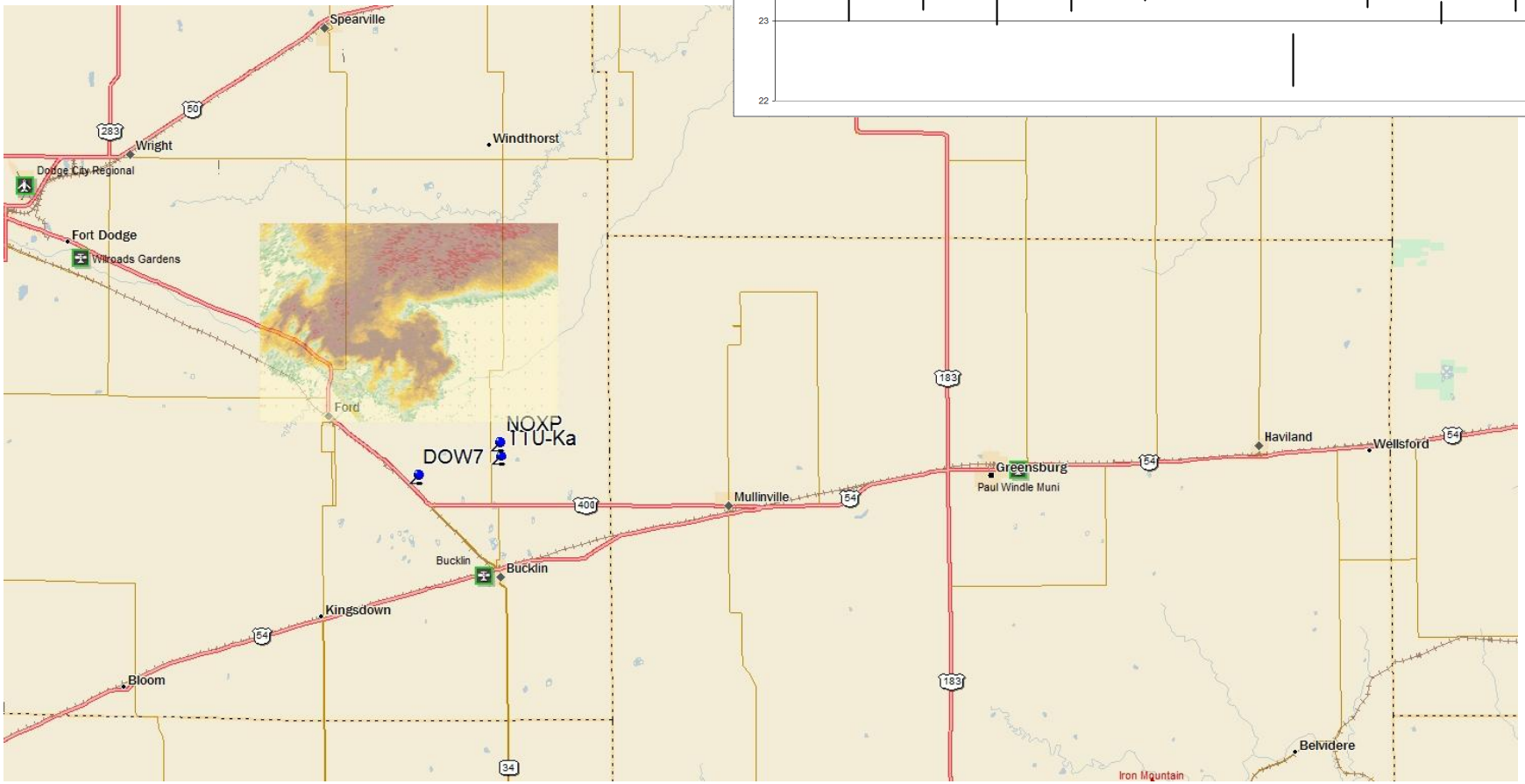


09 June 2009: Ford to Greensburg, Kansas

2325

14 minutes before genesis of marginal tornado

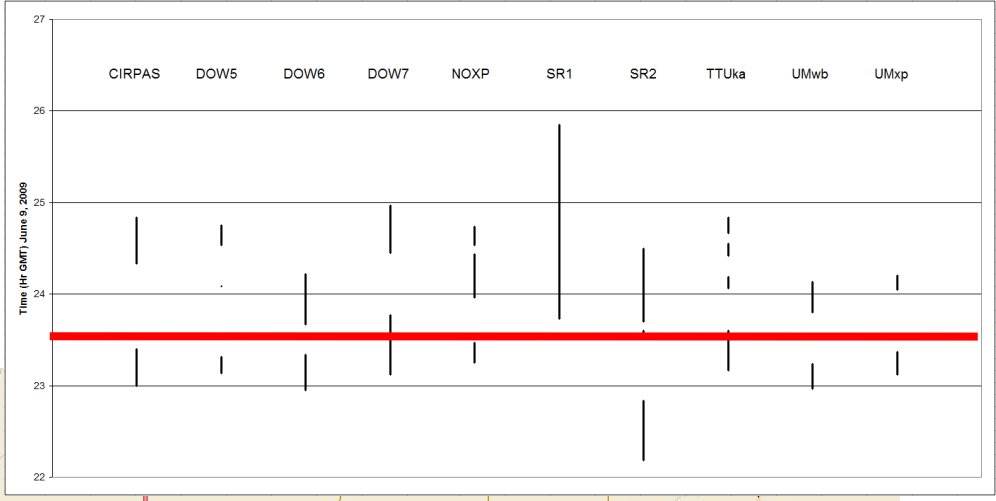


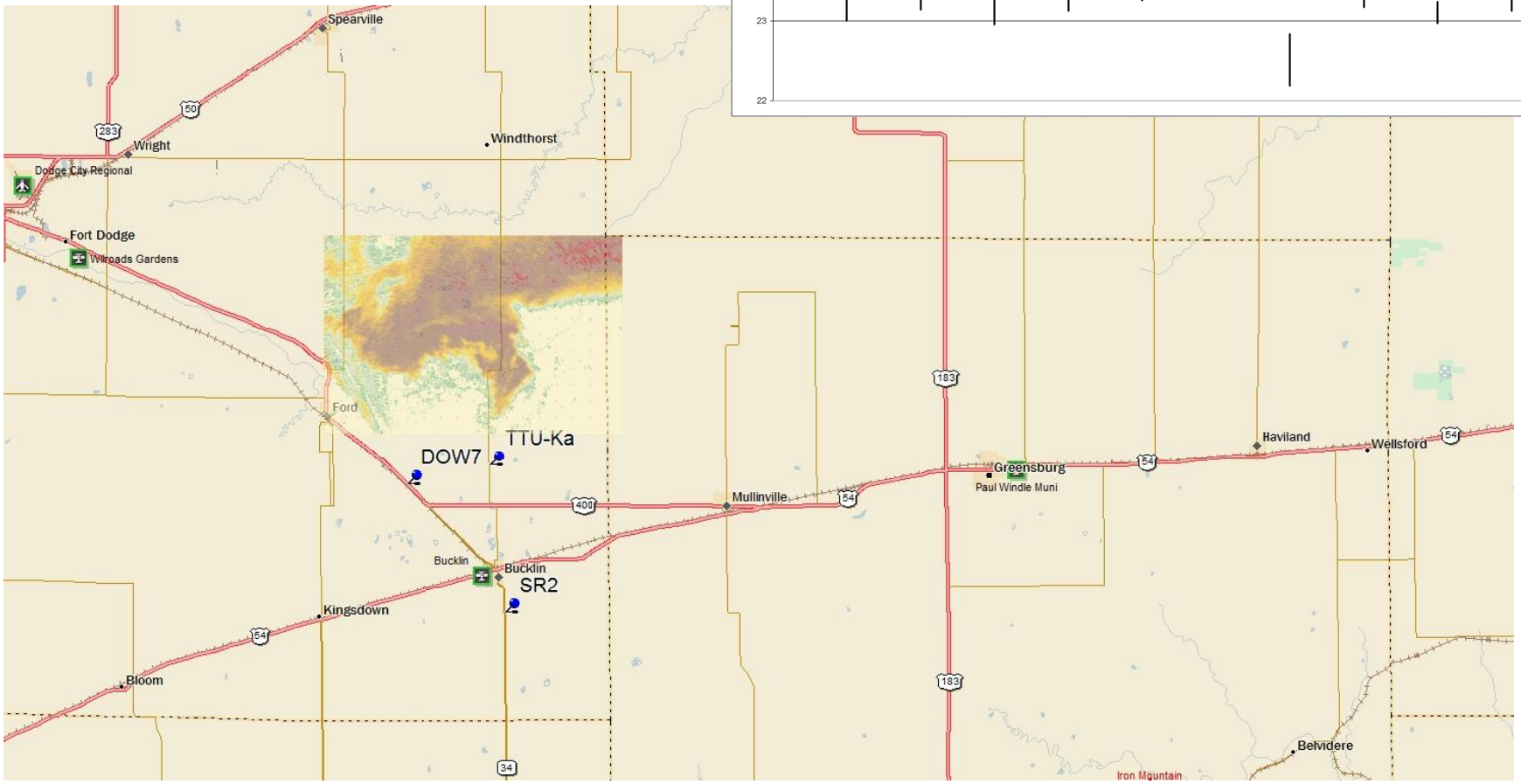


09 June 2009:

2331

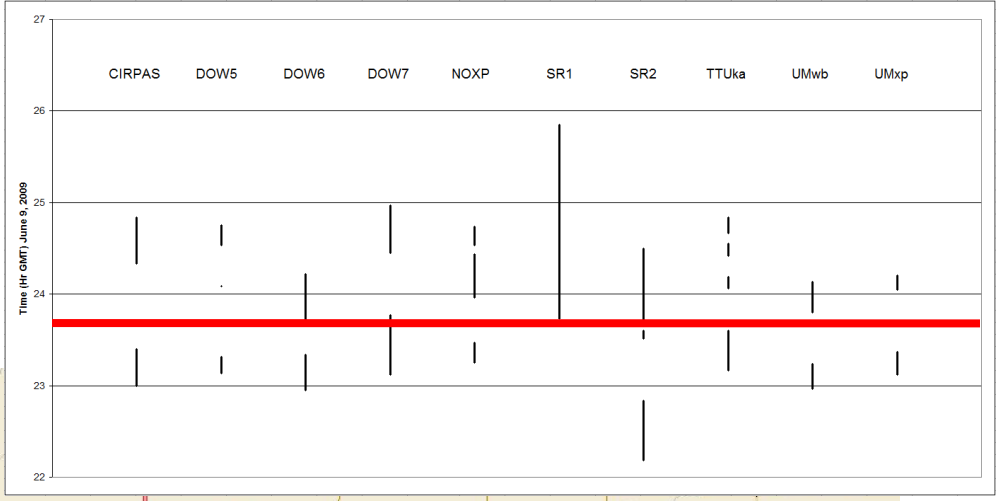
8 minutes before genesis of marginal tornado

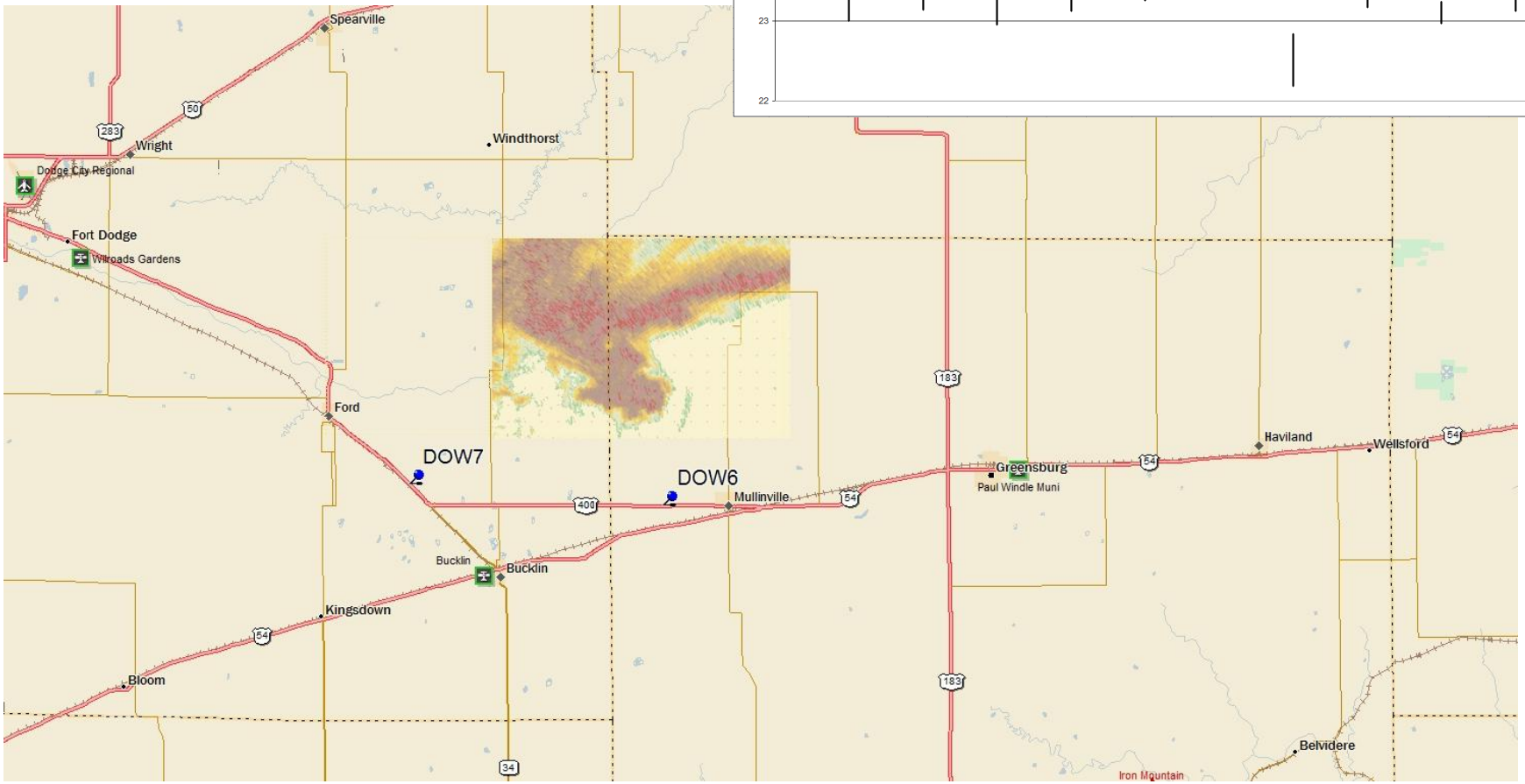




09 June 2009: Ford to Greensburg, Kansas
2340

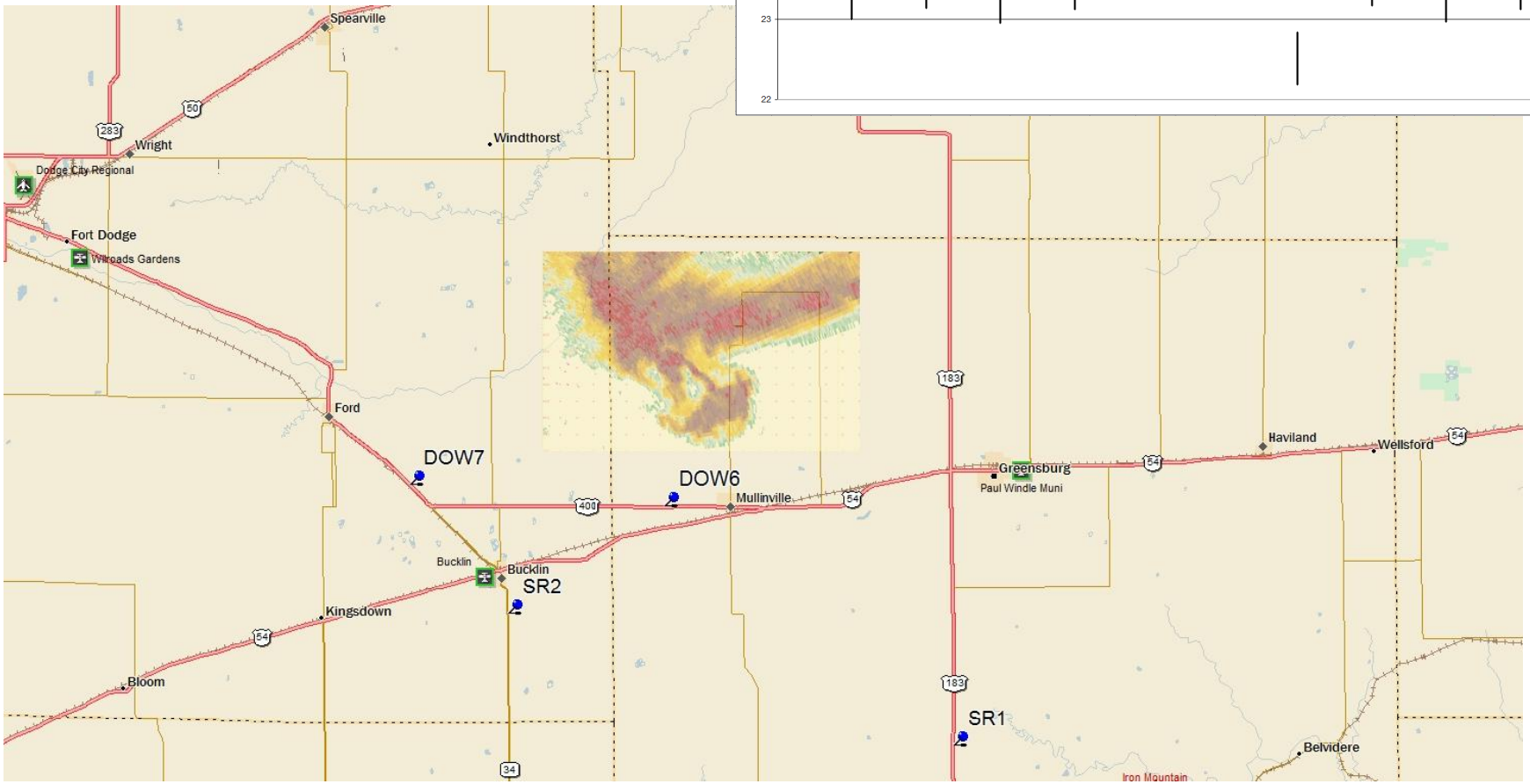
Marginal Tornado at this Time





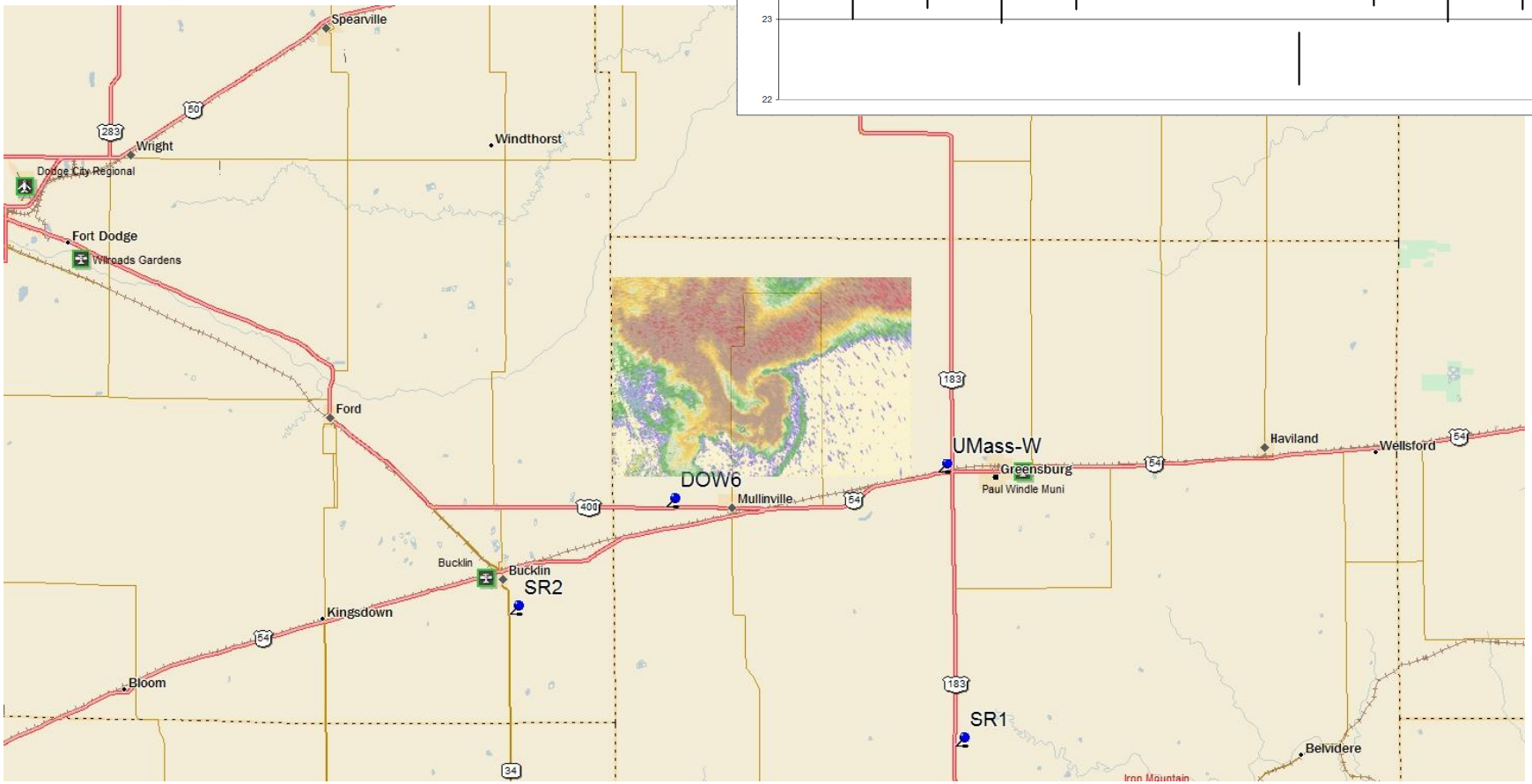
09 June 2009: Ford to Greensburg, Kansas
2345

No tornado
First storm scale dd about this time.



09 June 2009: Ford to Greensburg, Kansas
2350

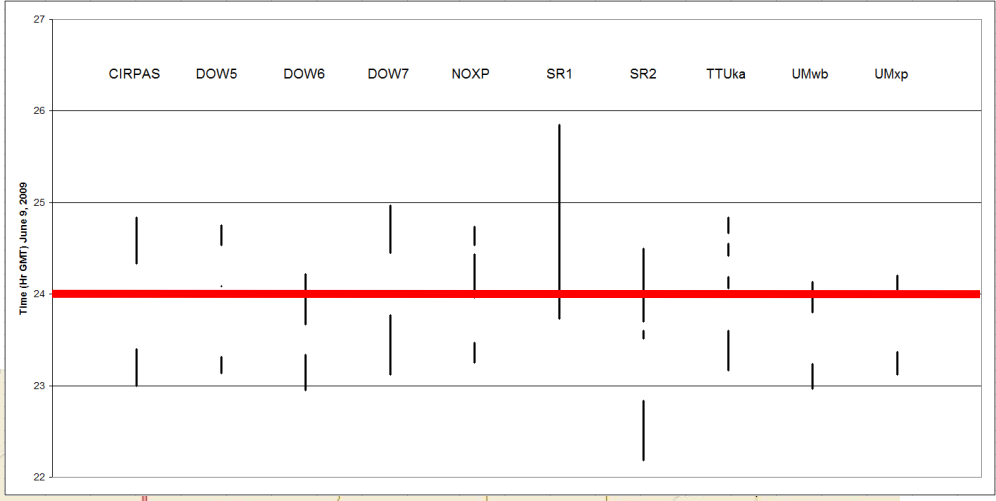
Marginal Tornado one minute before this time
Storm scale dd. Only single Doppler mesoscale

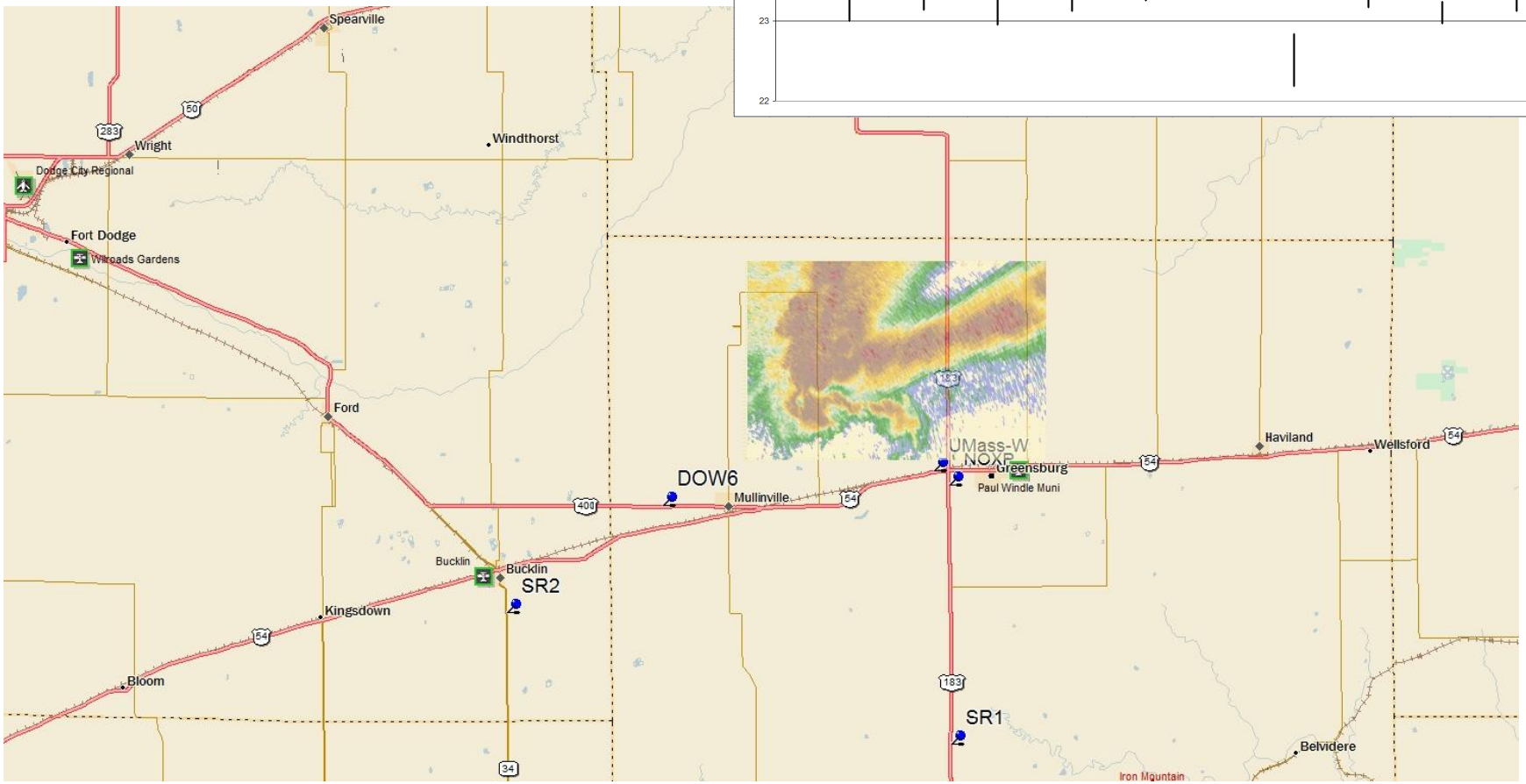


09 June 2009: Ford to Greensburg, Kansas

0000

1st Mesoscale and Stormscale nested

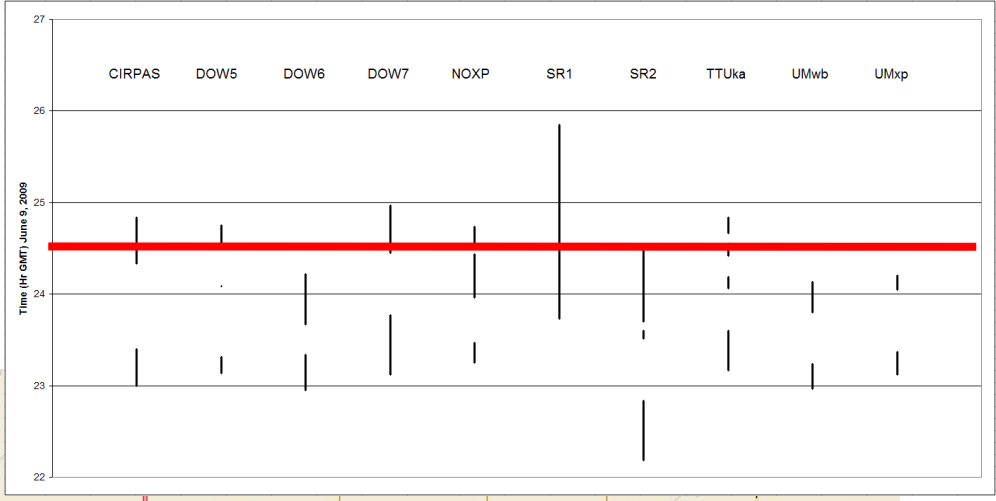


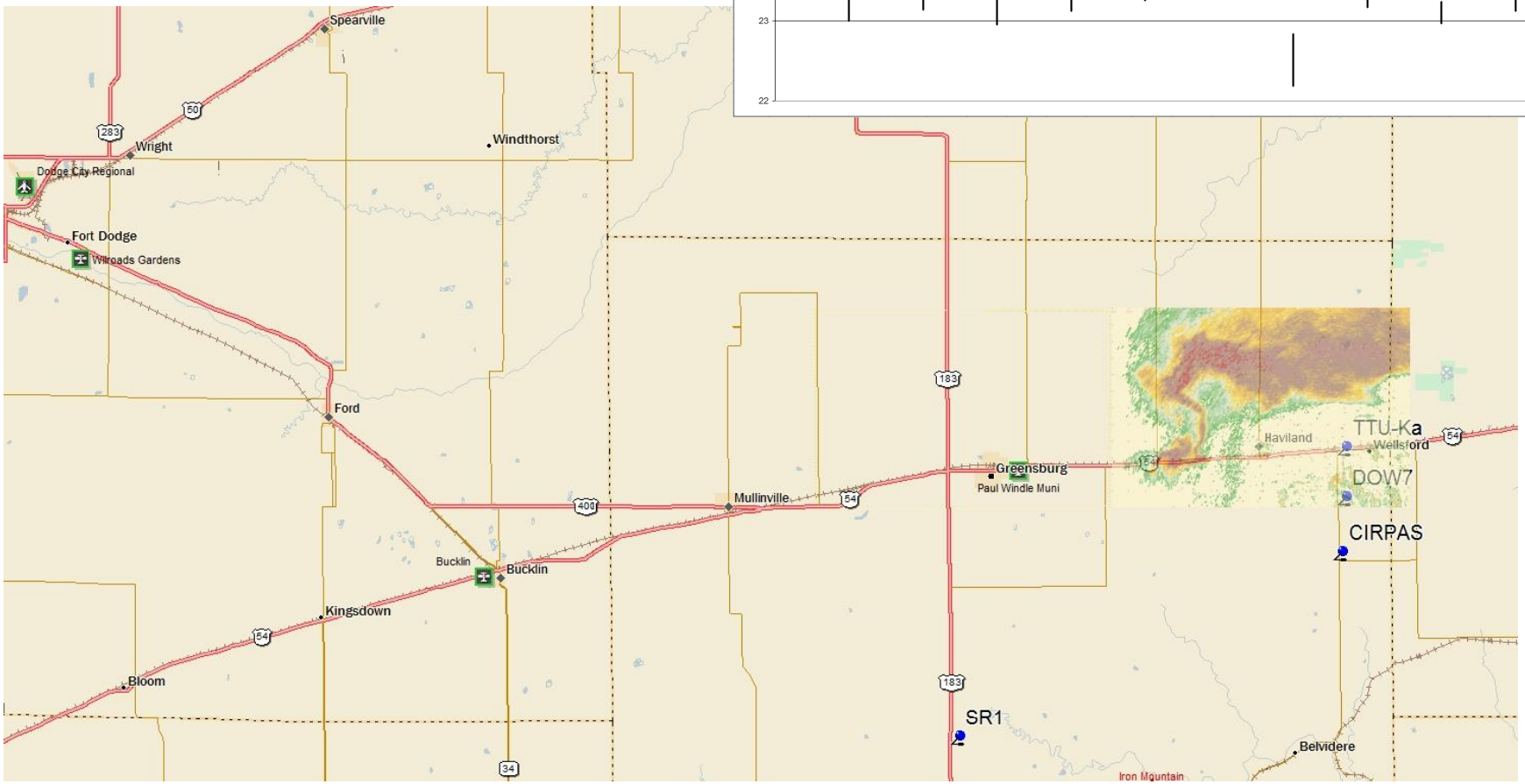


09 June 2009: Ford to Greensburg, Kansas

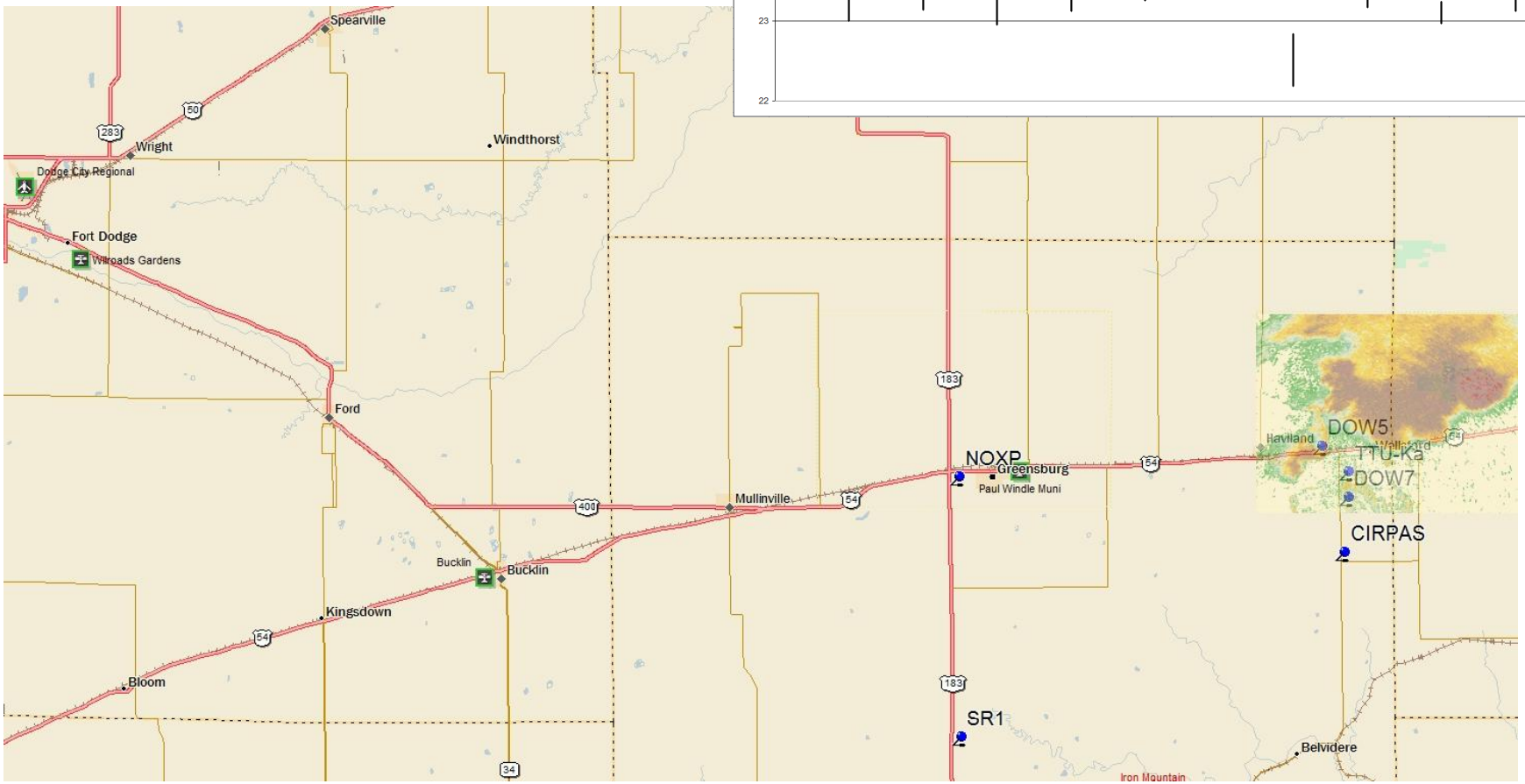
0030:

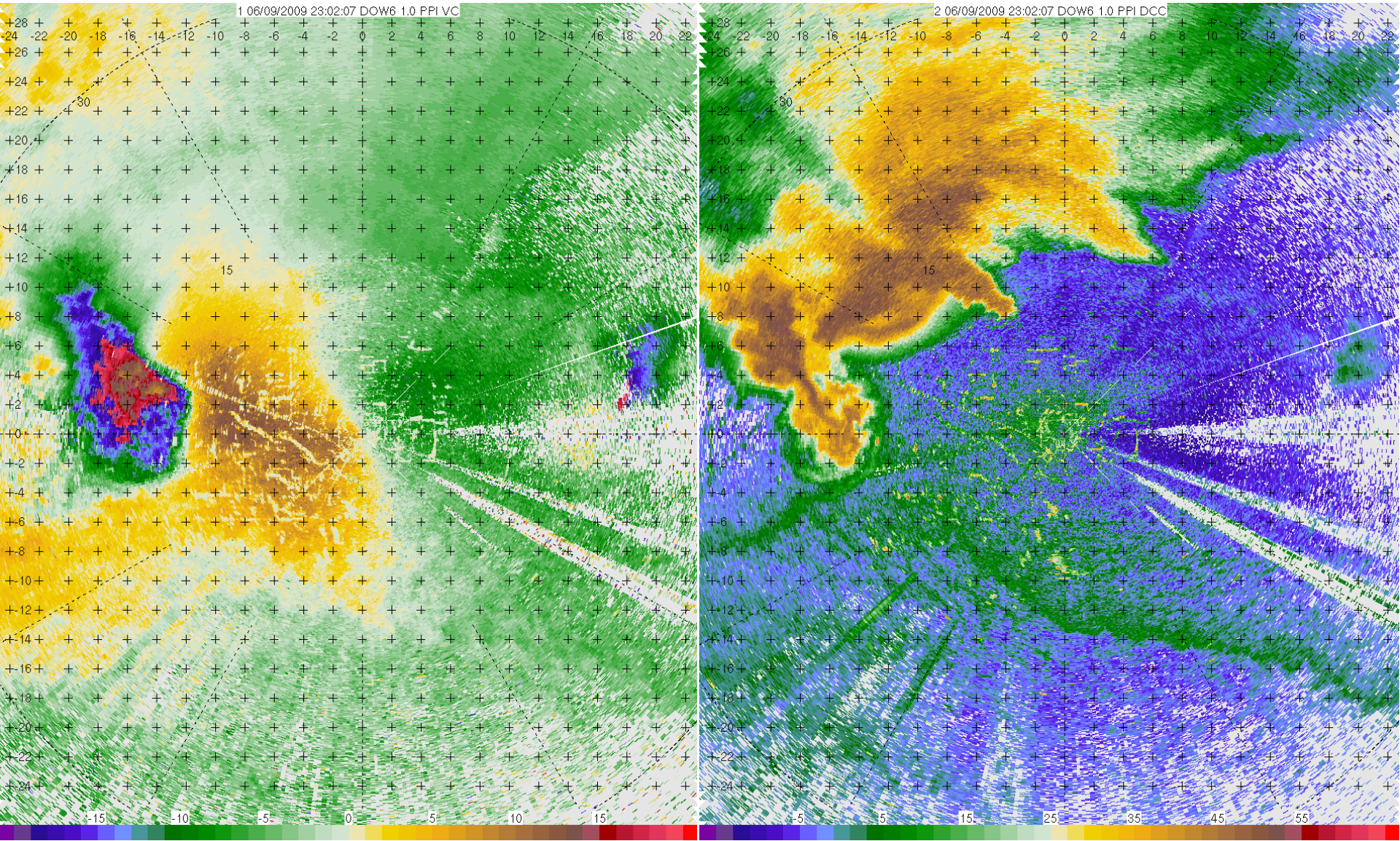
DD with SR1 and DOW7

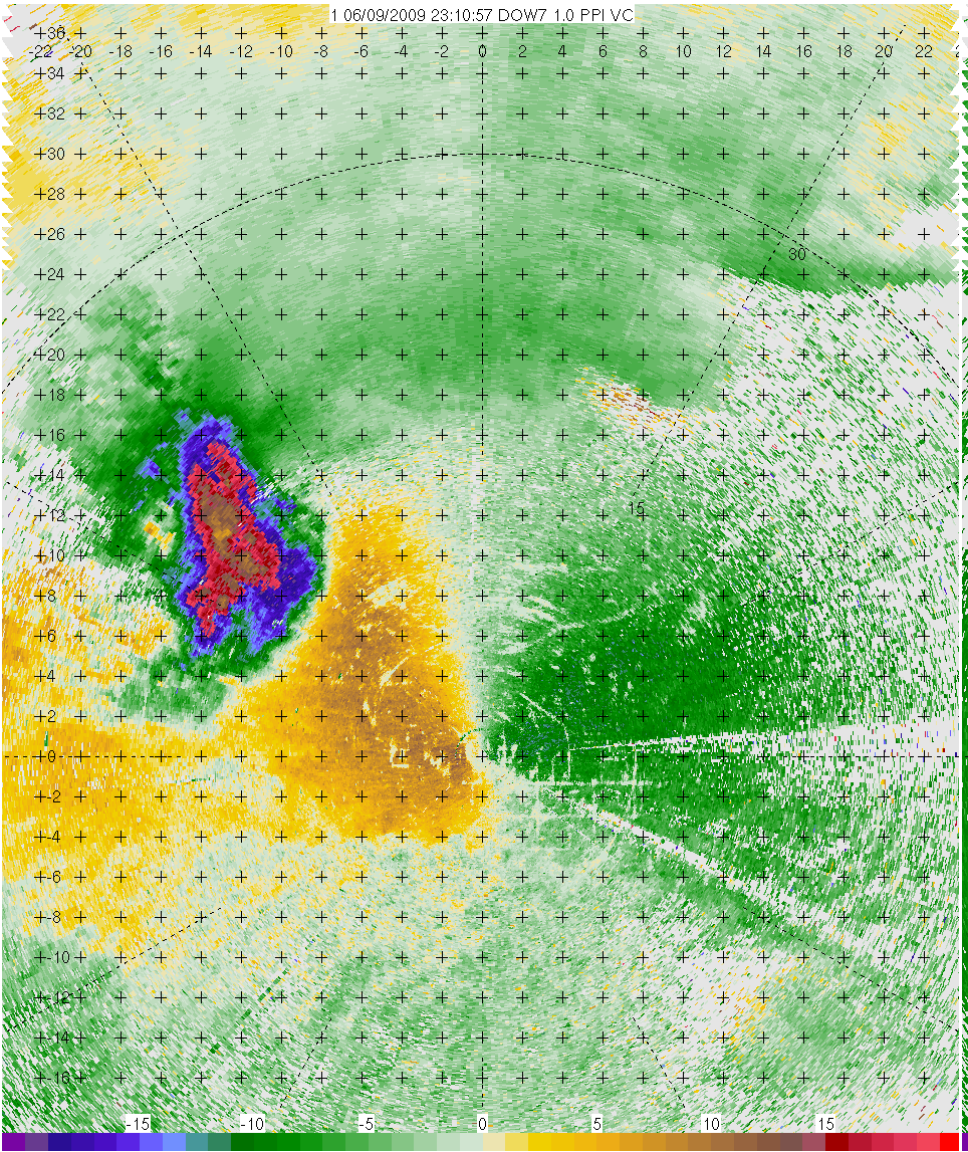


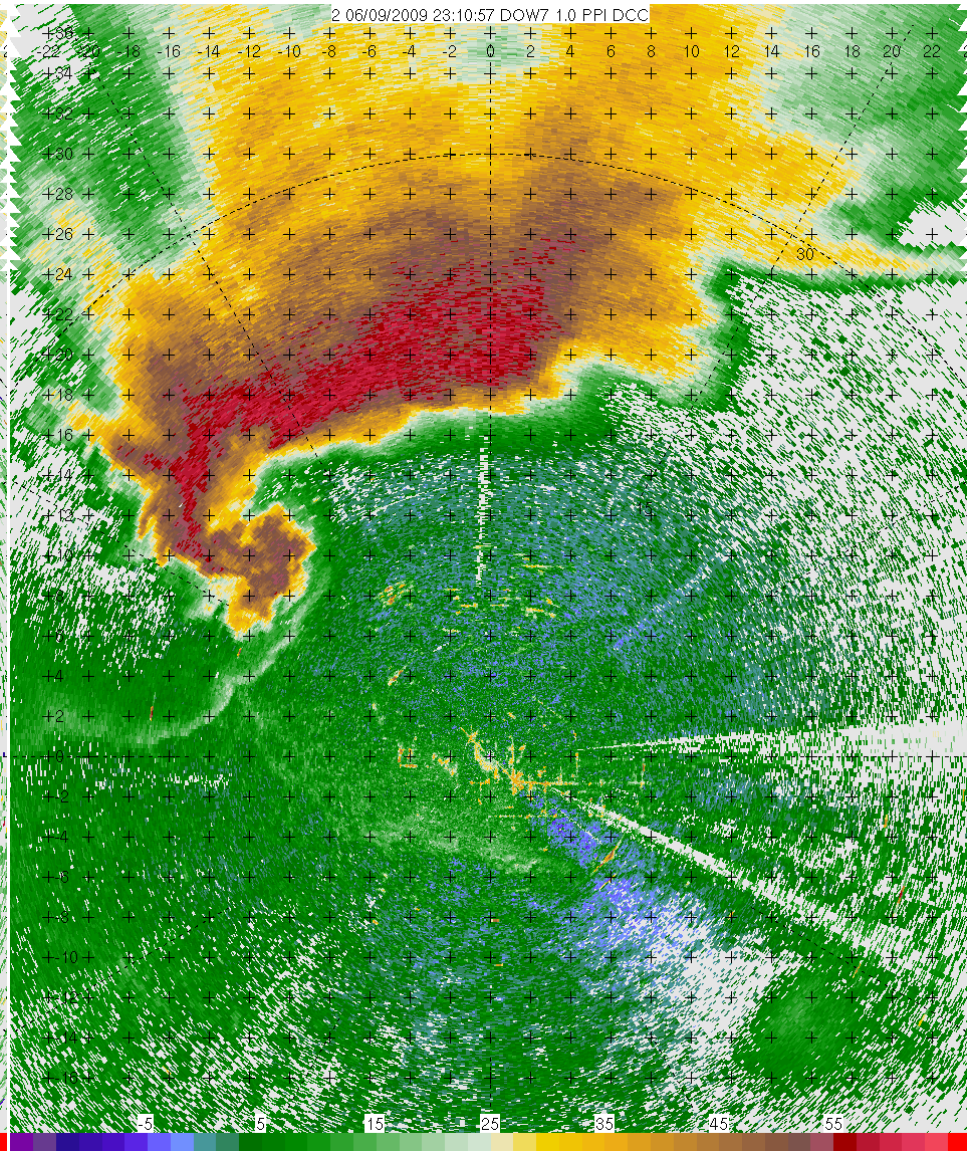


09 June 2009: Ford to Greensburg, Kansas



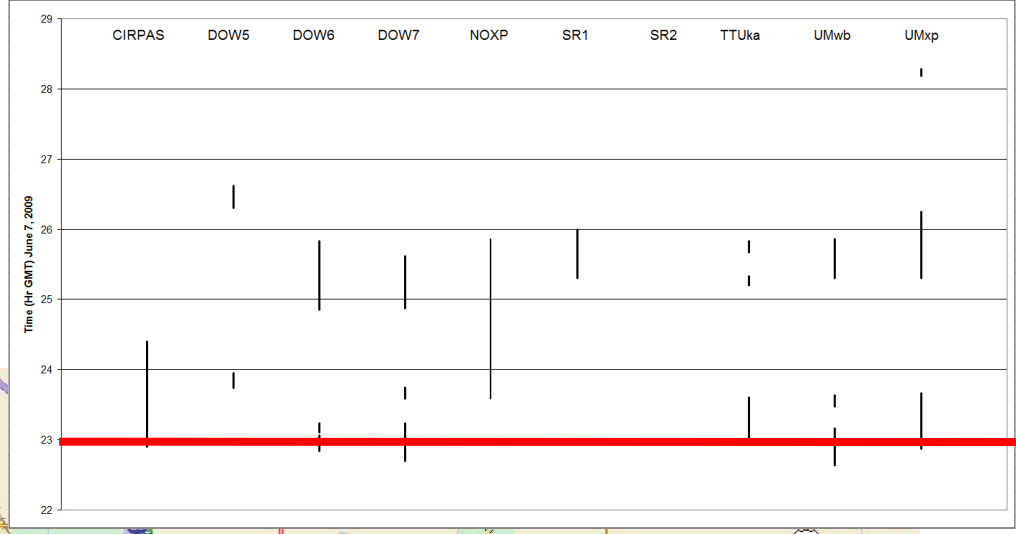

1 06/09/2009 23:02:07 DOW6 1.0 PPI VC
2 06/09/2009 23:02:07 DOW6 1.0 PPI DCC

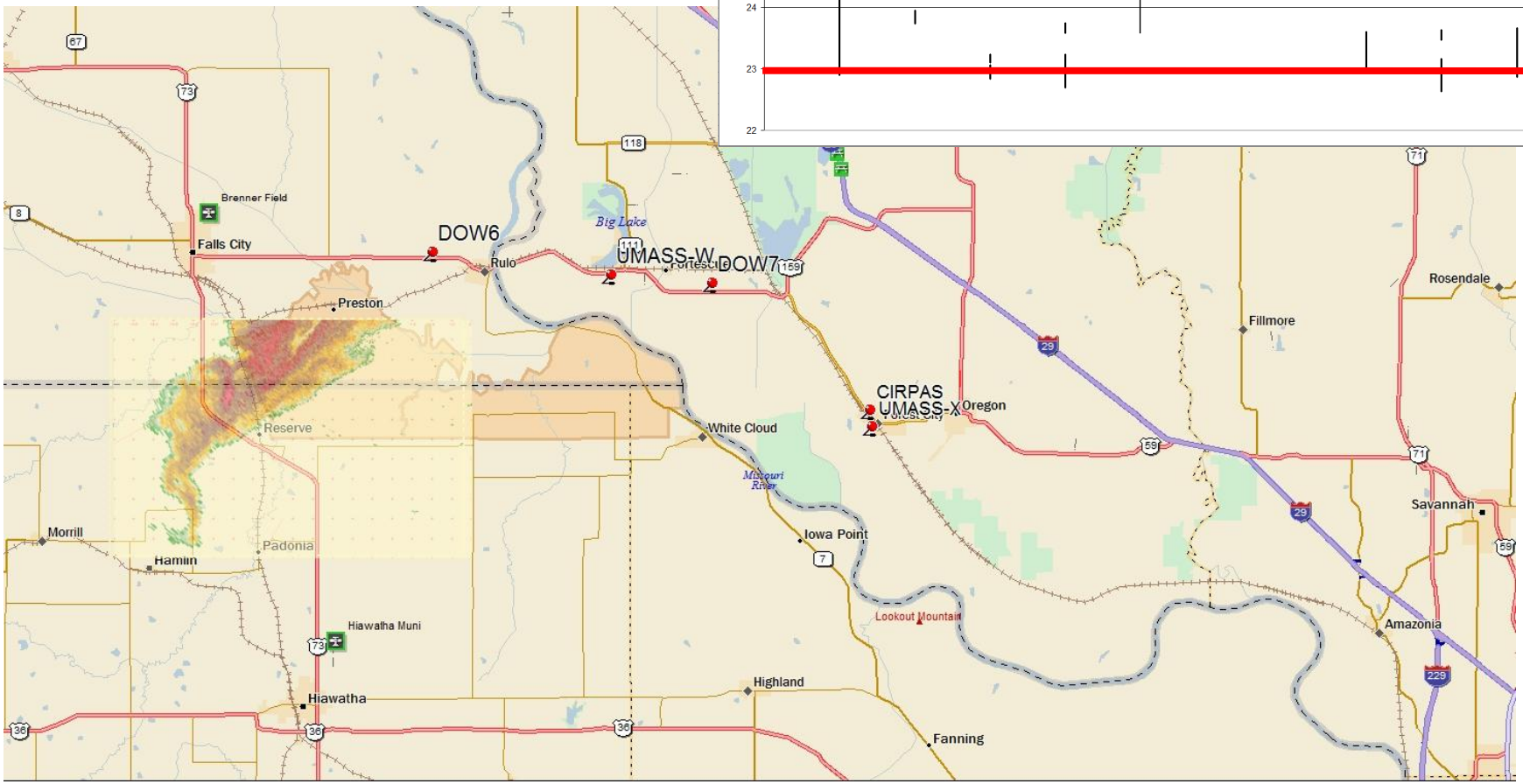

1 06/09/2009 23:10:57 DOW7 1.0 PPI VC
-15
-10
-5
0
5
10
15


2 06/09/2009 23:10:57 DOW7 1.0 PPI DCC
-5
5
15
25
35
45
55

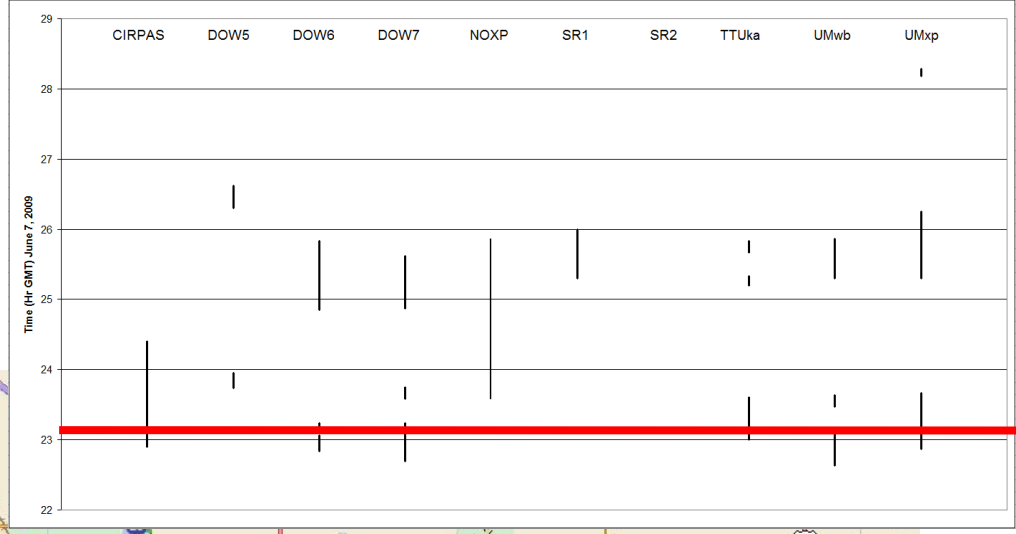
07 June

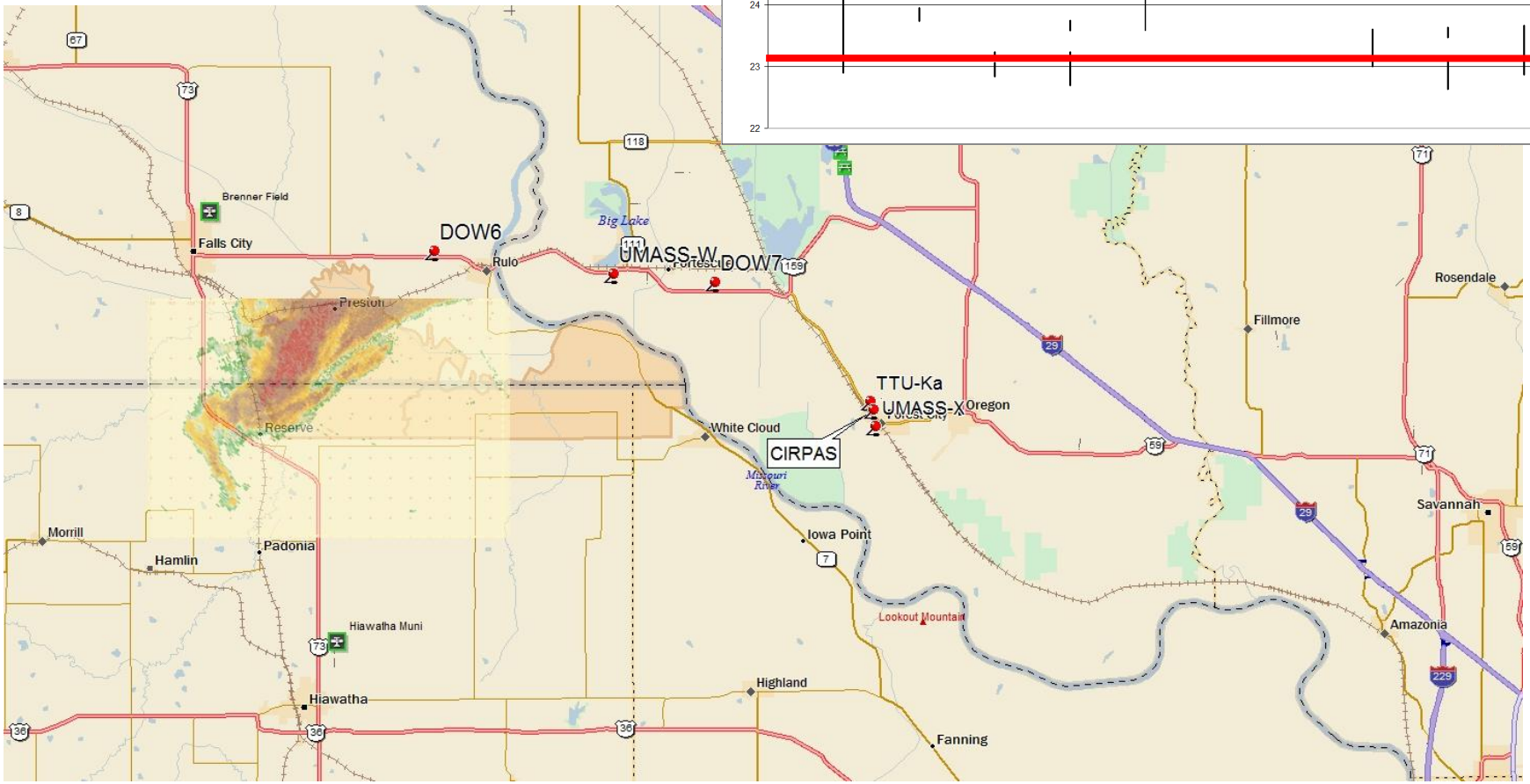
7 June 2009 – 2256 – Rulo, NE



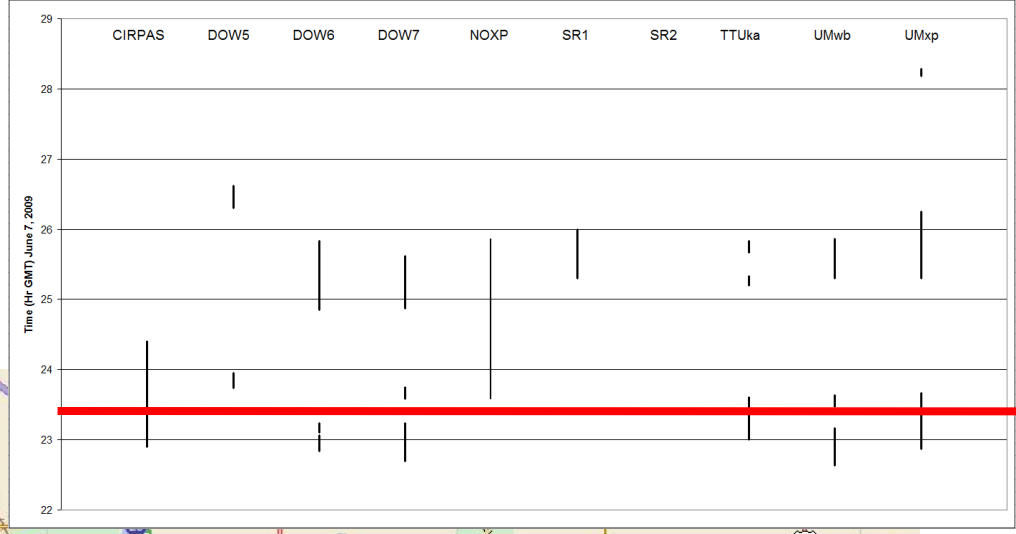


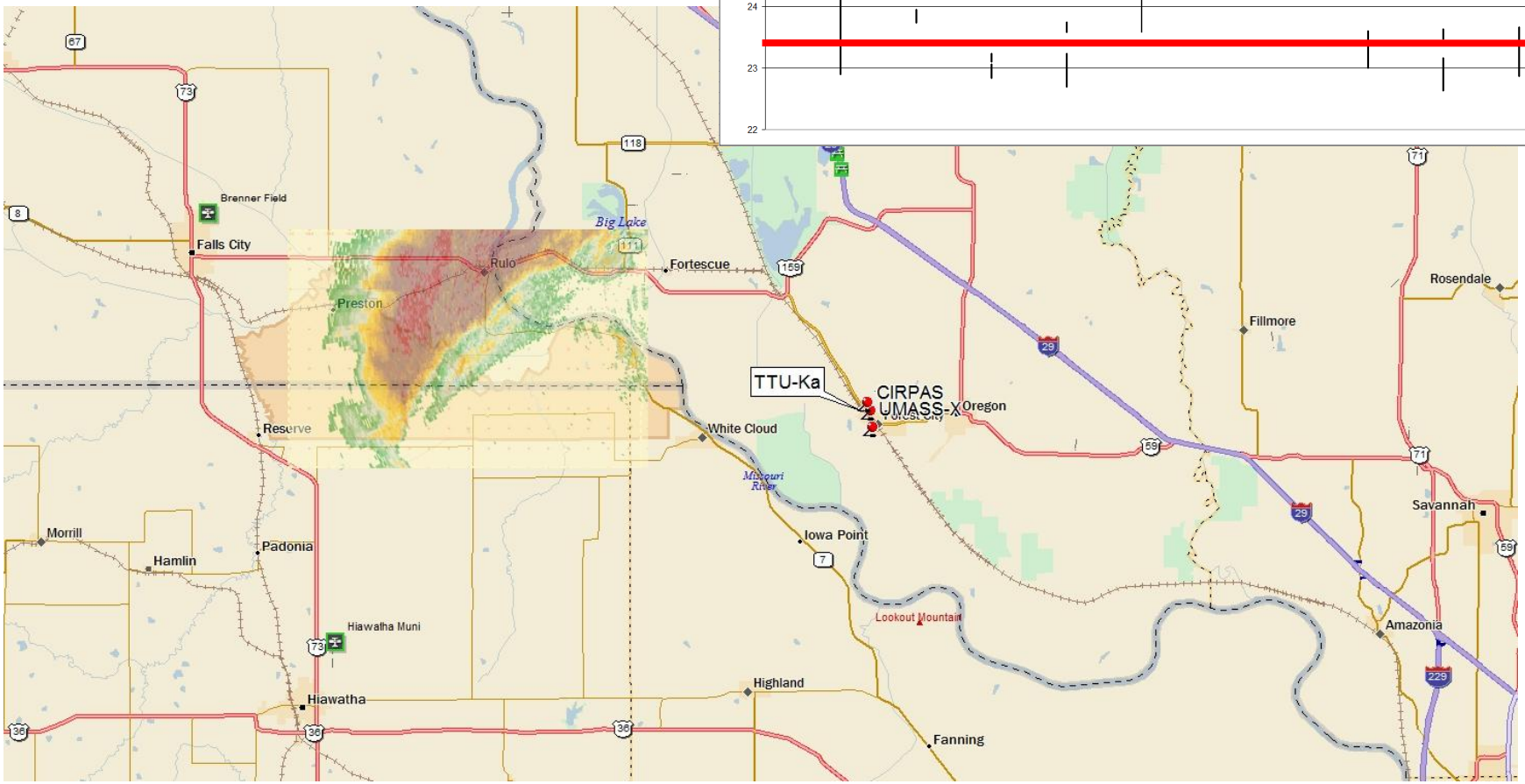
7 June 2009 – 2300 – Rulo, NE



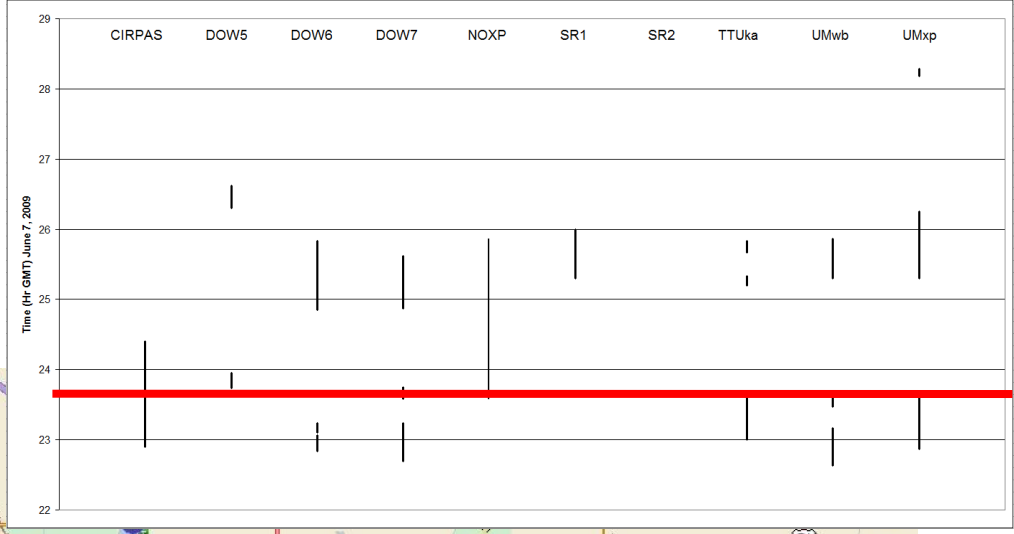


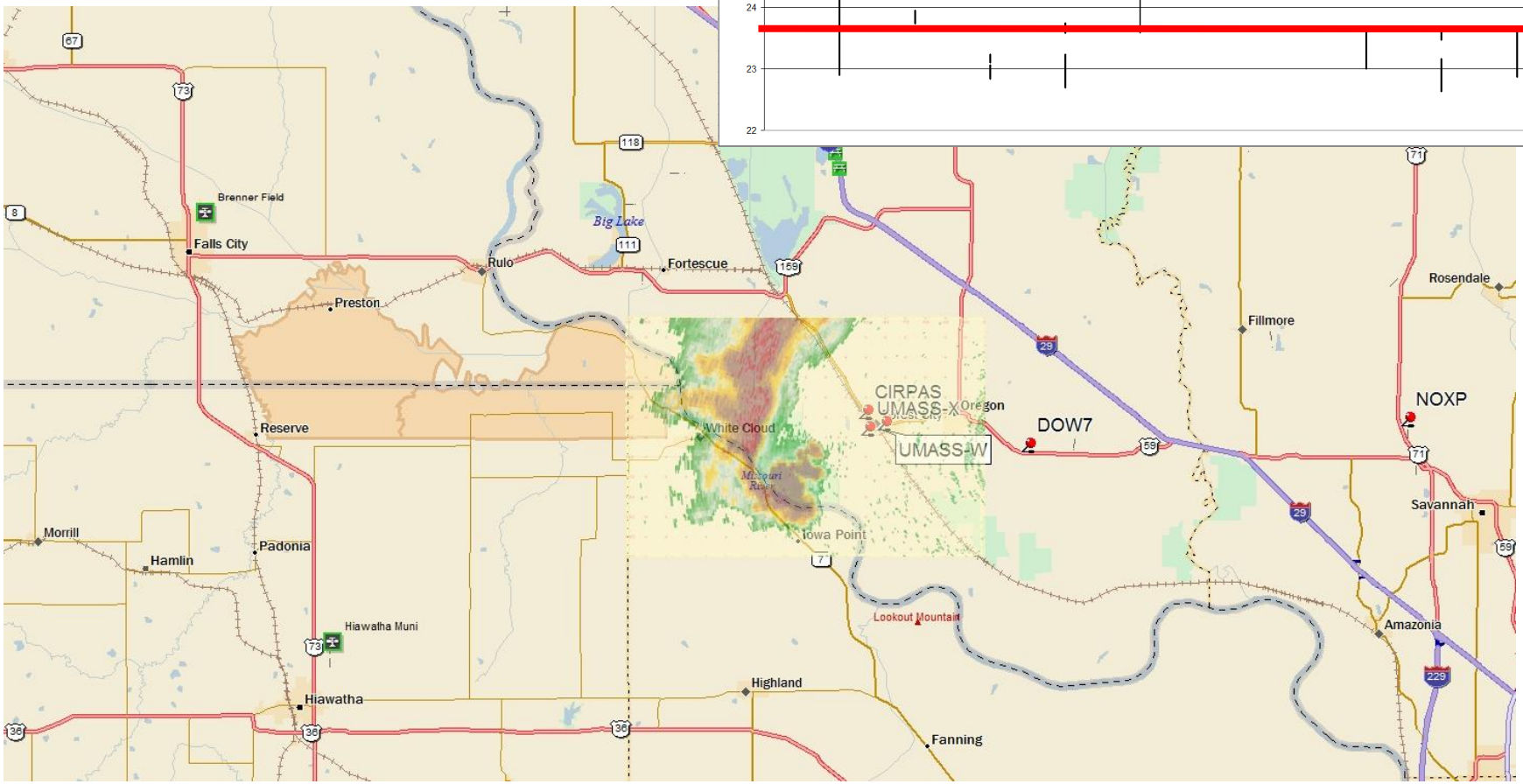
7 June 2009 – 2315 – Rulo, NE



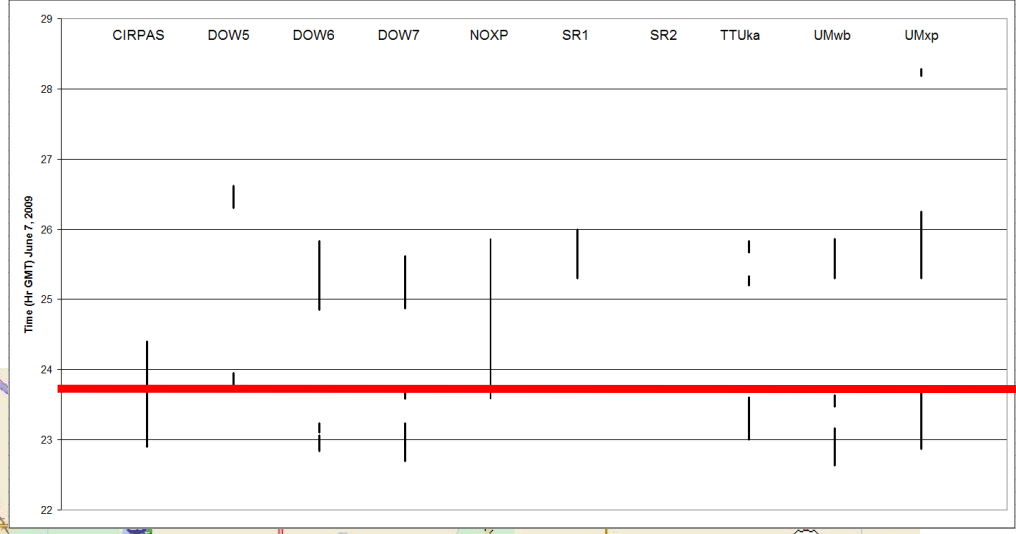


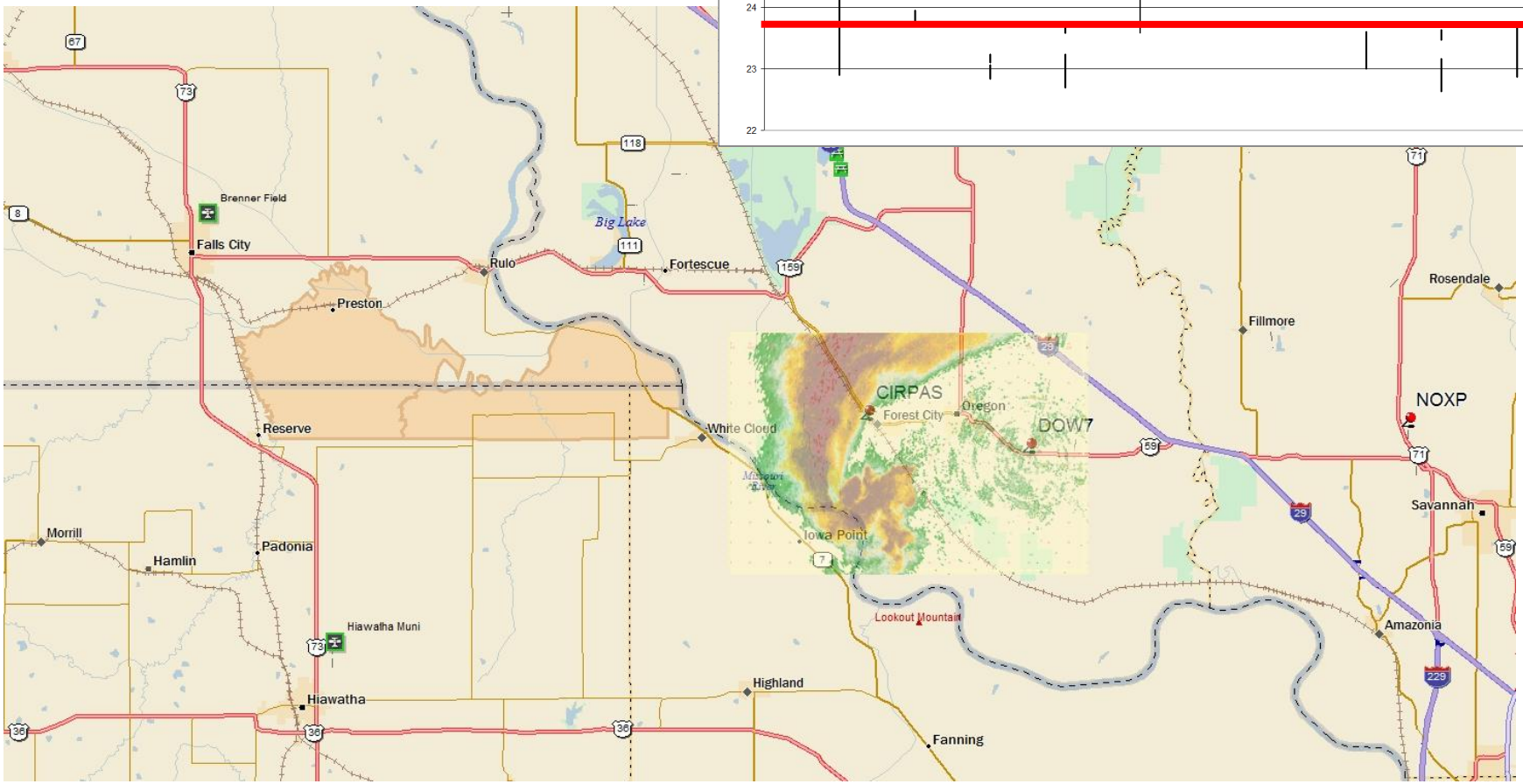
7 June 2009 – 2336 – Oregon, MO



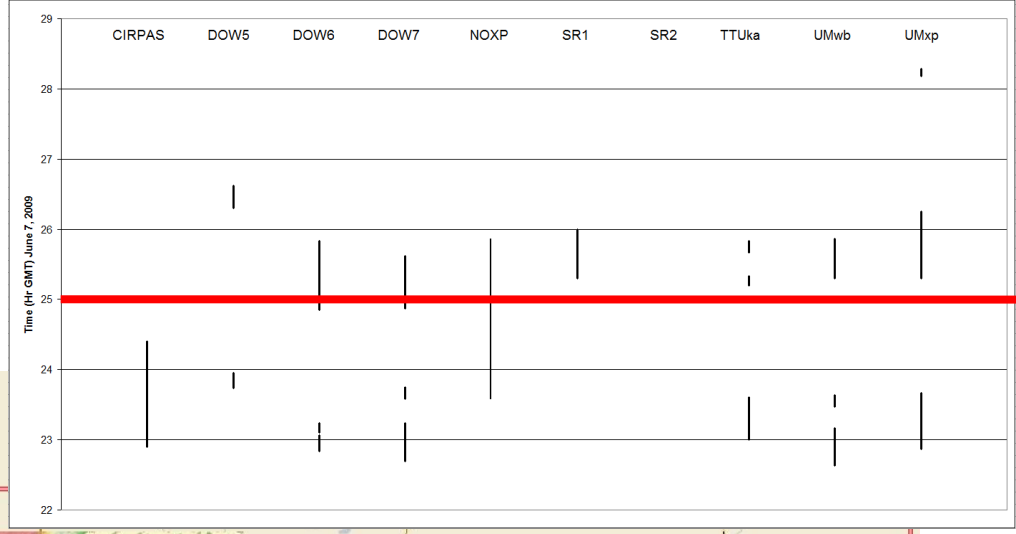


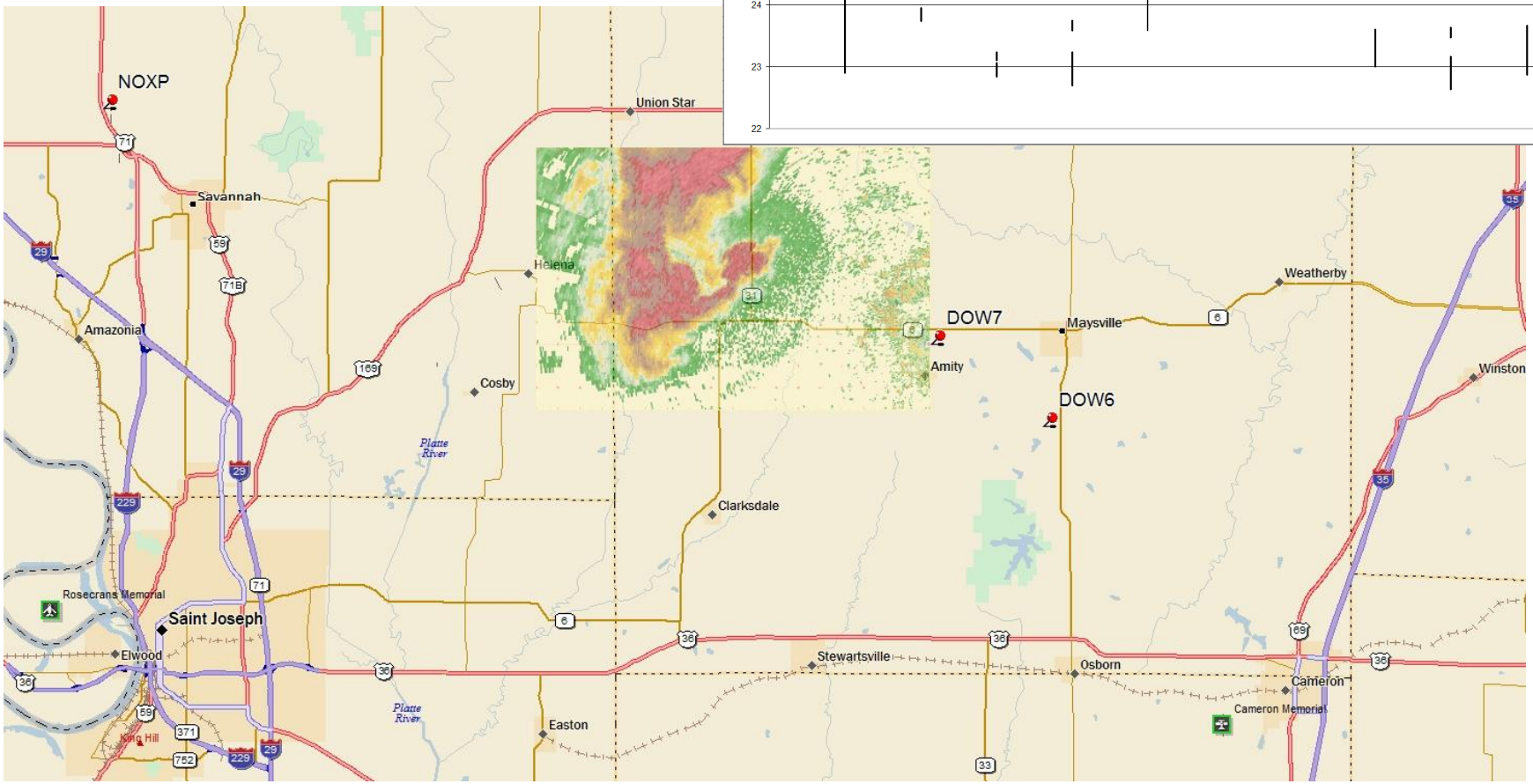
7 June 2009 – 2341 – Oregon, MO



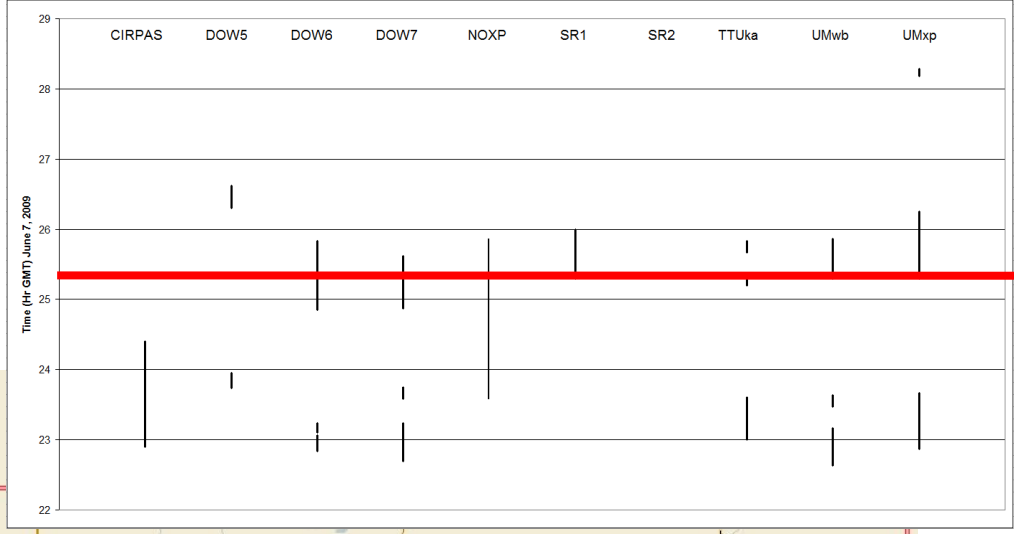


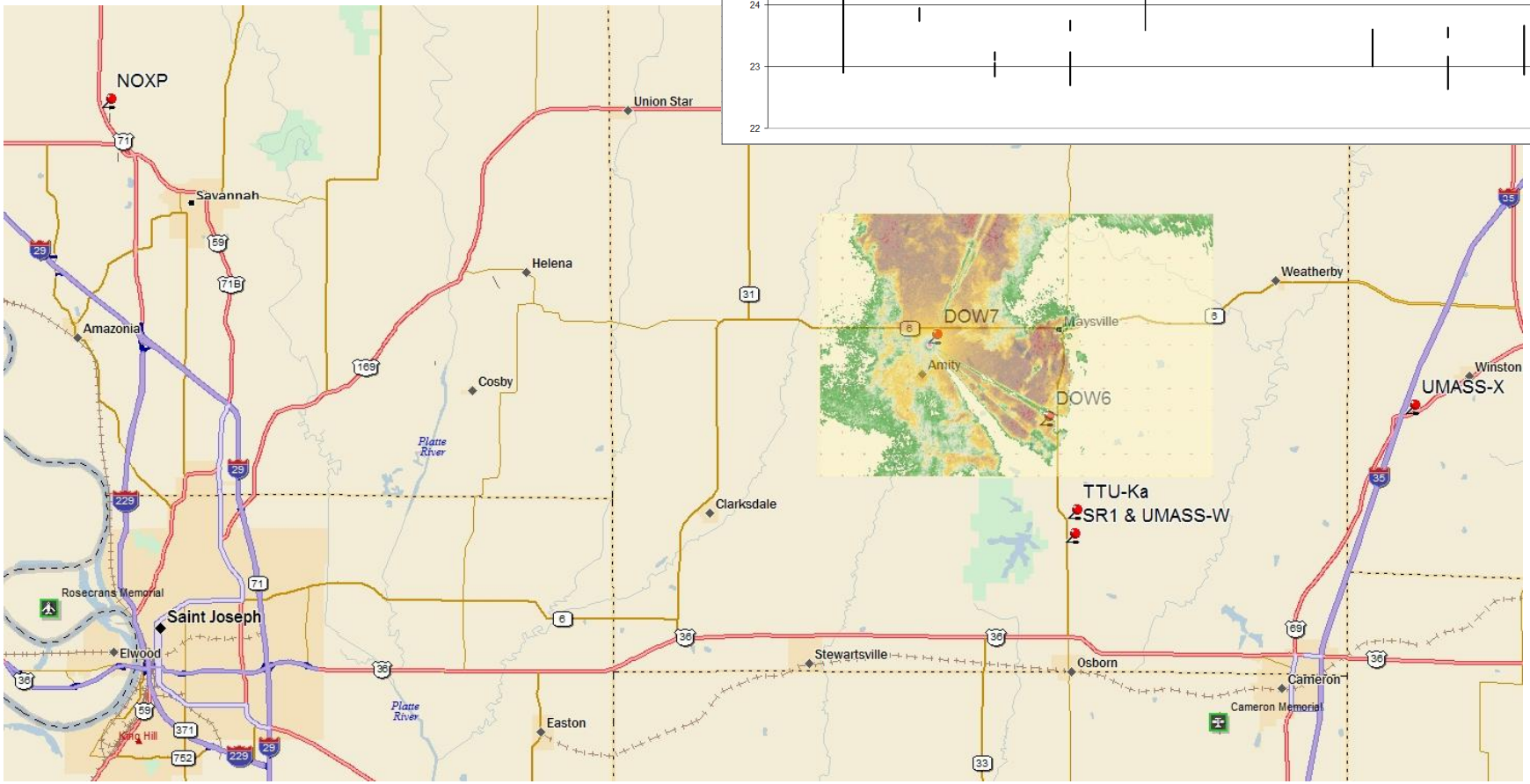
7 June 2009 – 0052 – Helena, MO



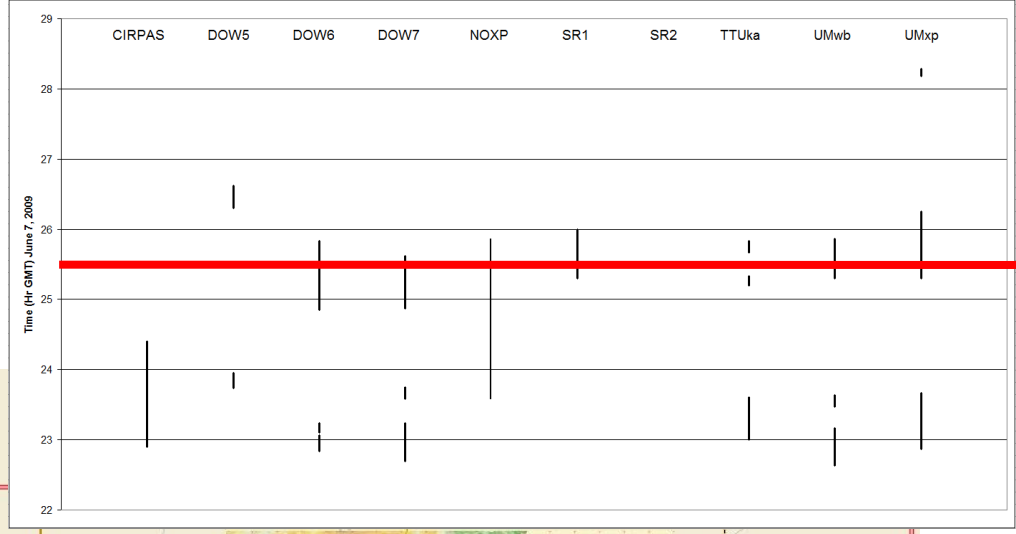


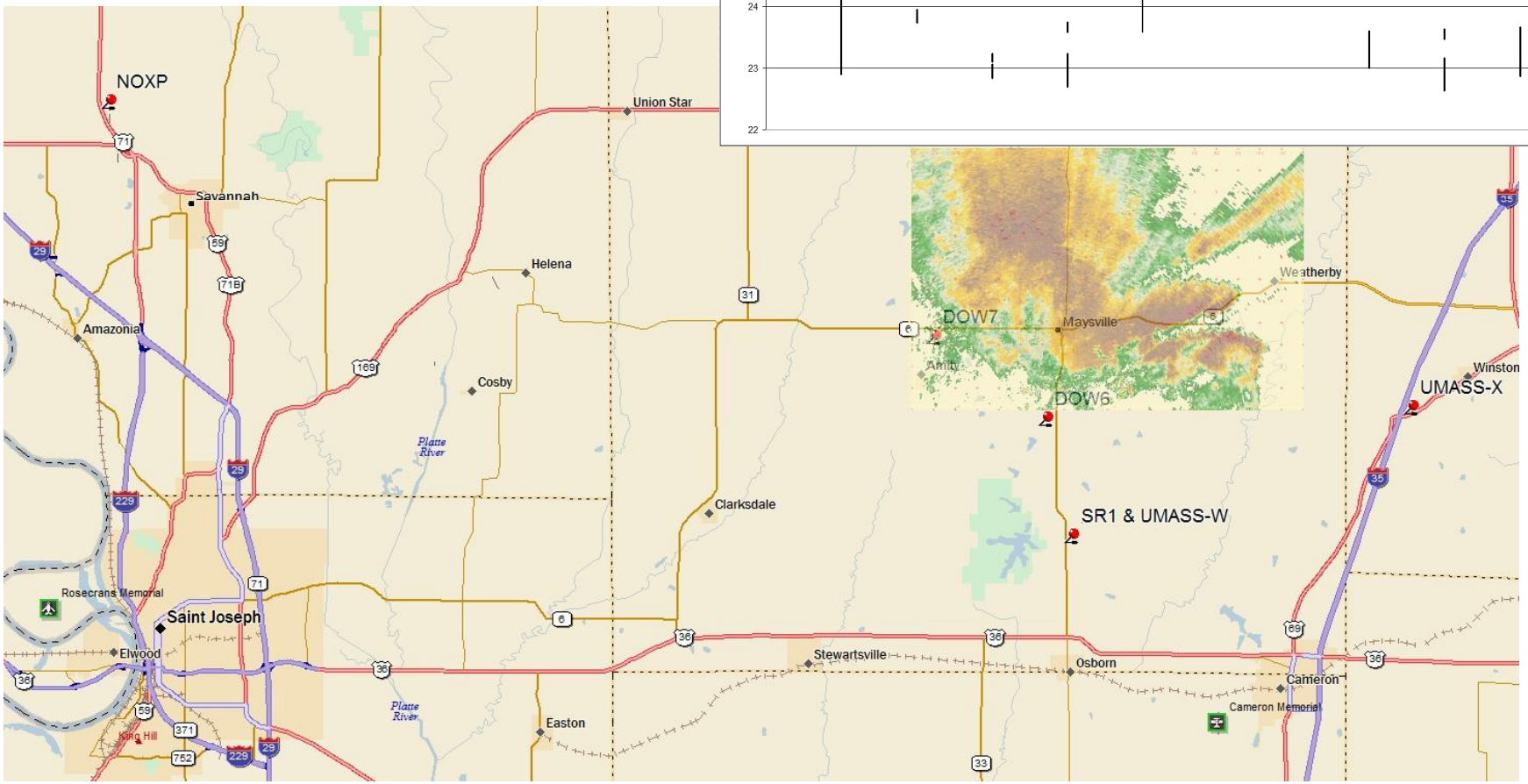
7 June 2009 – 0118 – Amity, MO



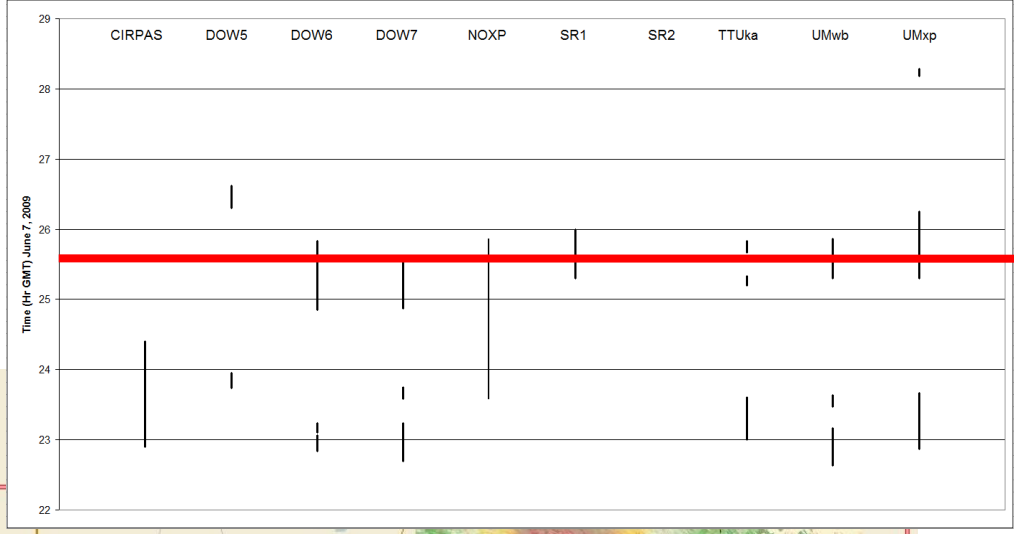


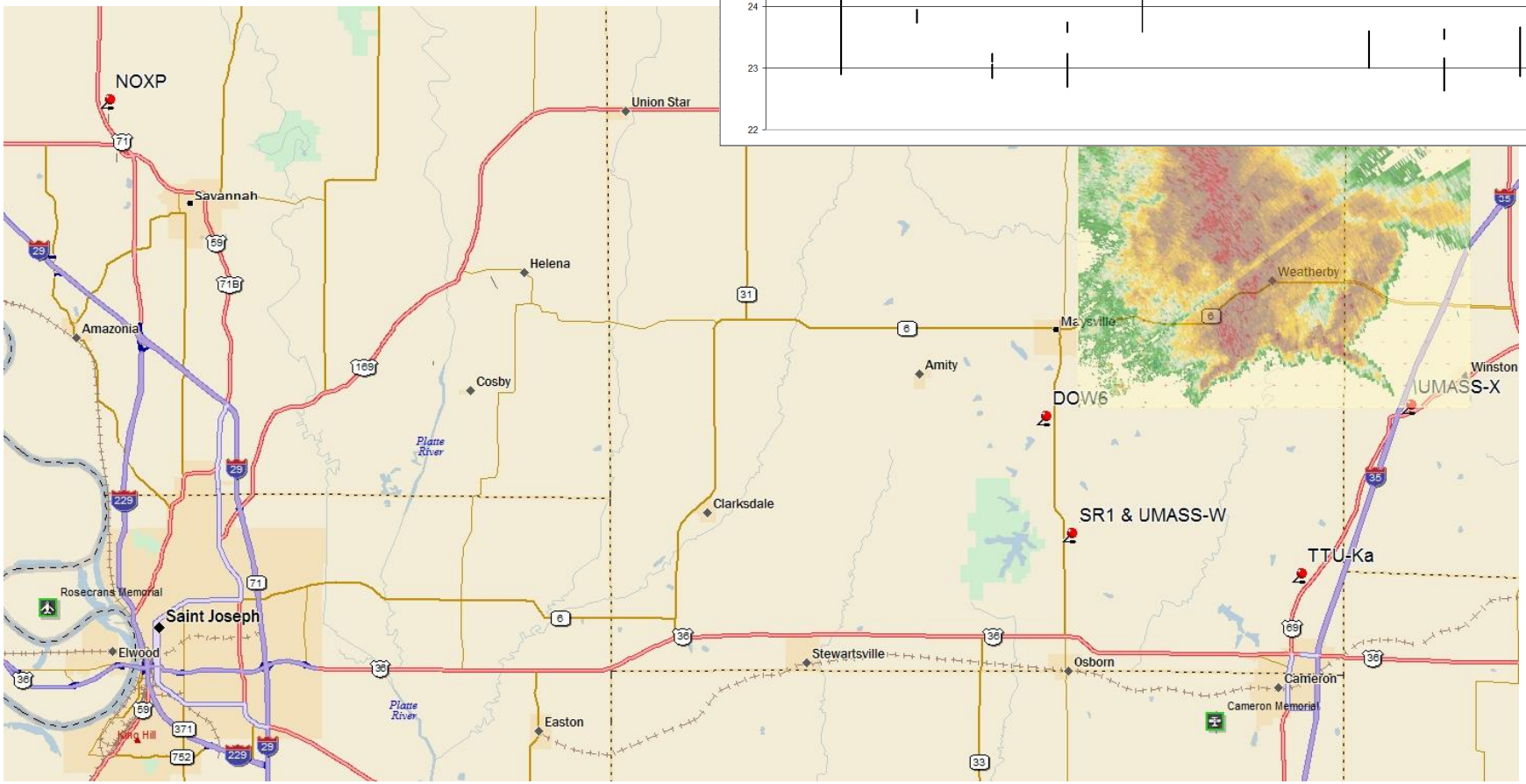
7 June 2009 – 0135 – Maysville, MO



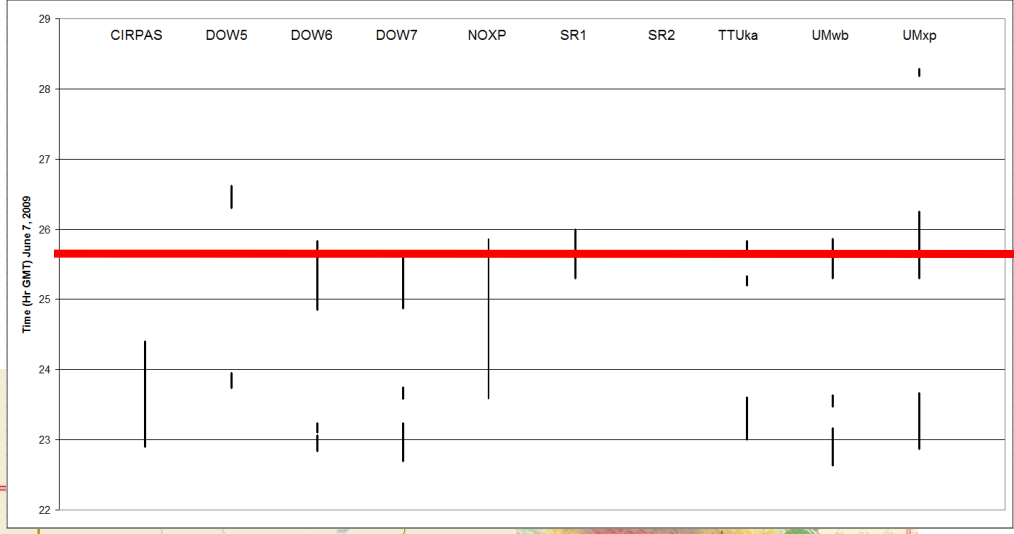


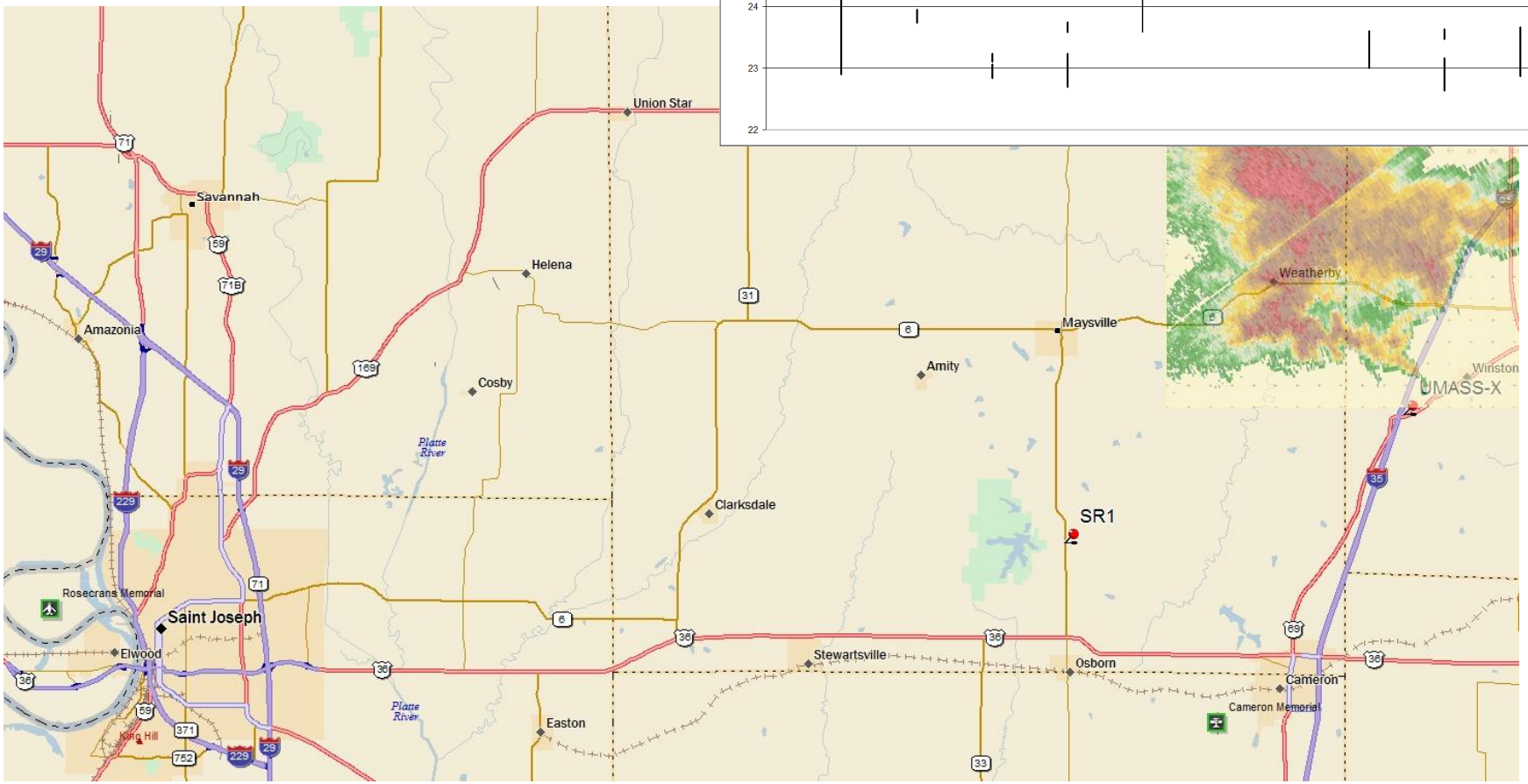
7 June 2009 – 0145 – Weatherby, MO



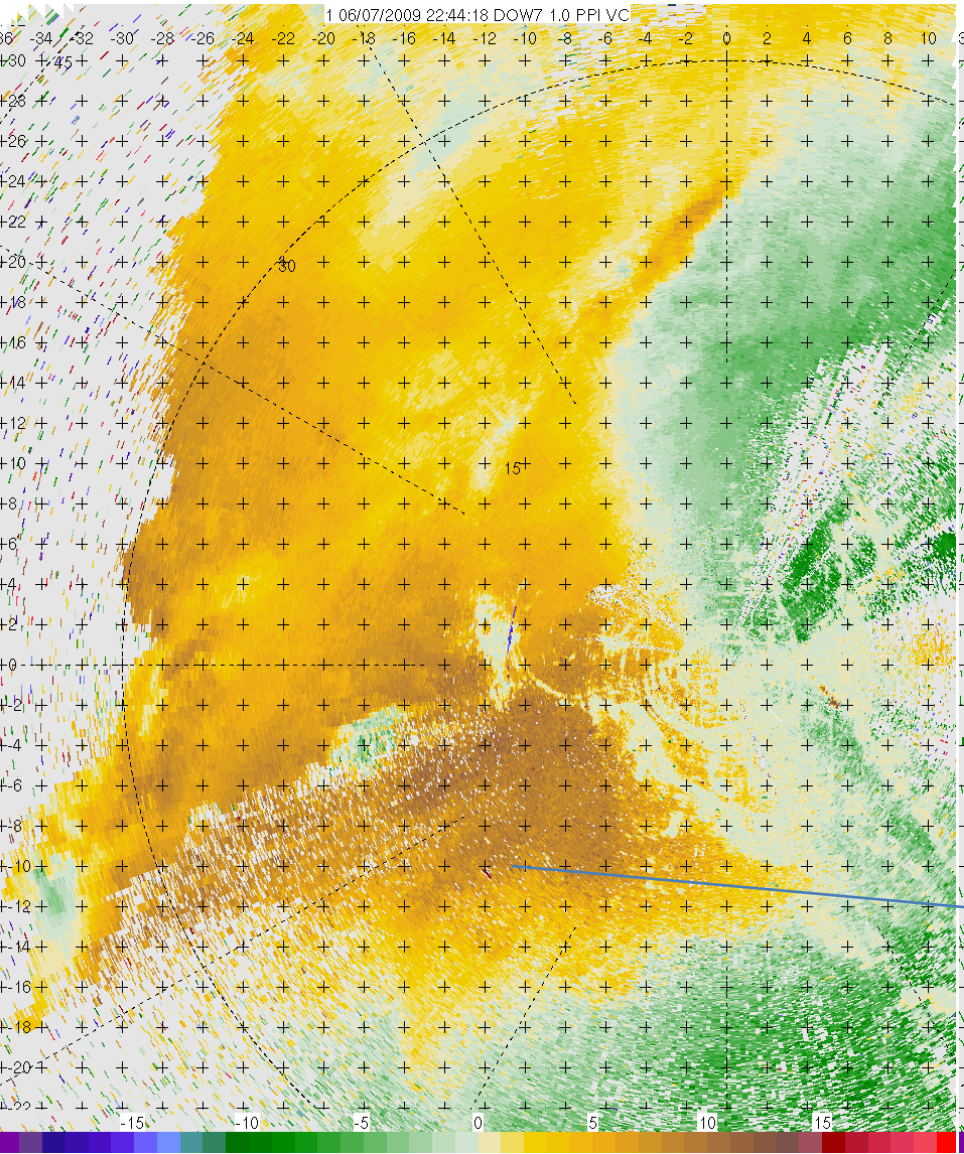


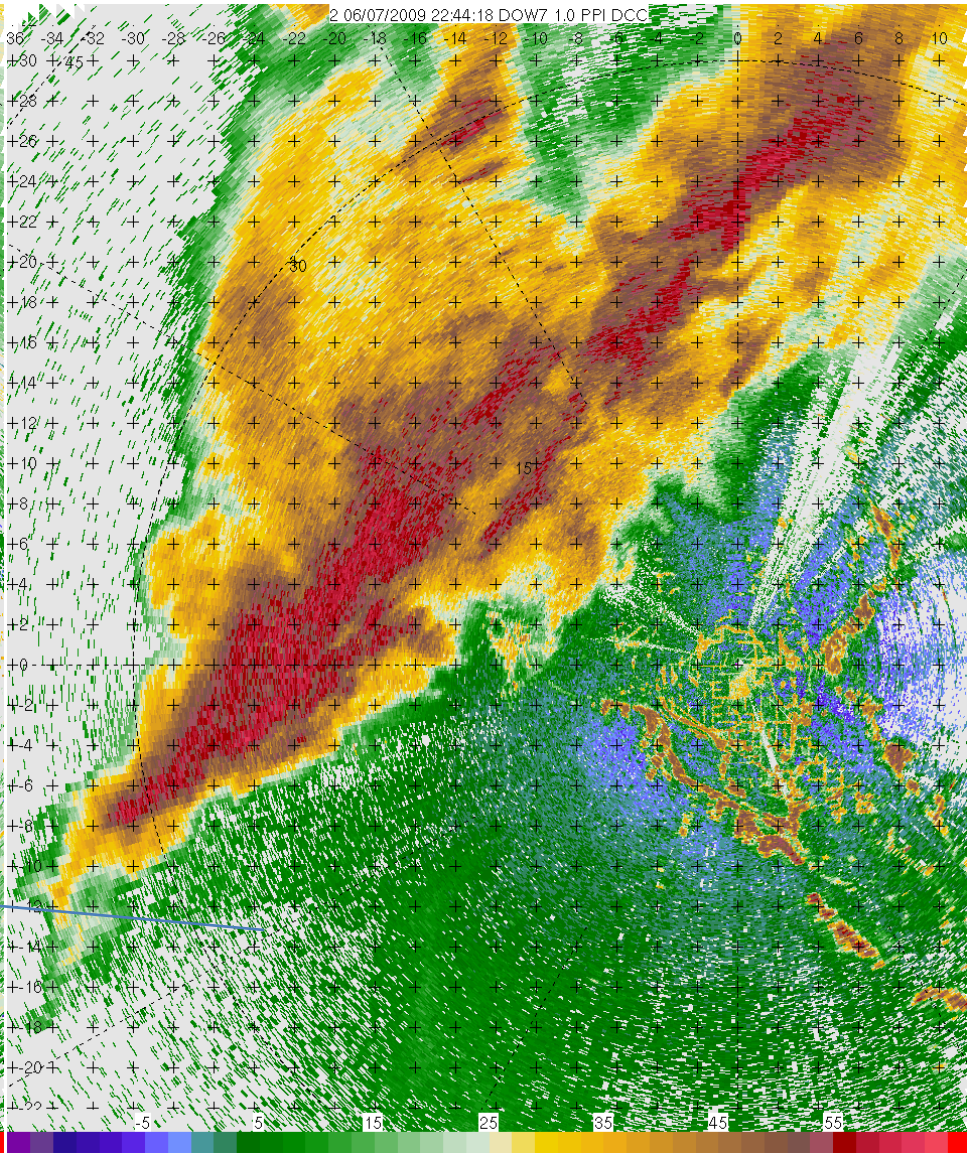
7 June 2009 – 0152 – Weatherby, MO



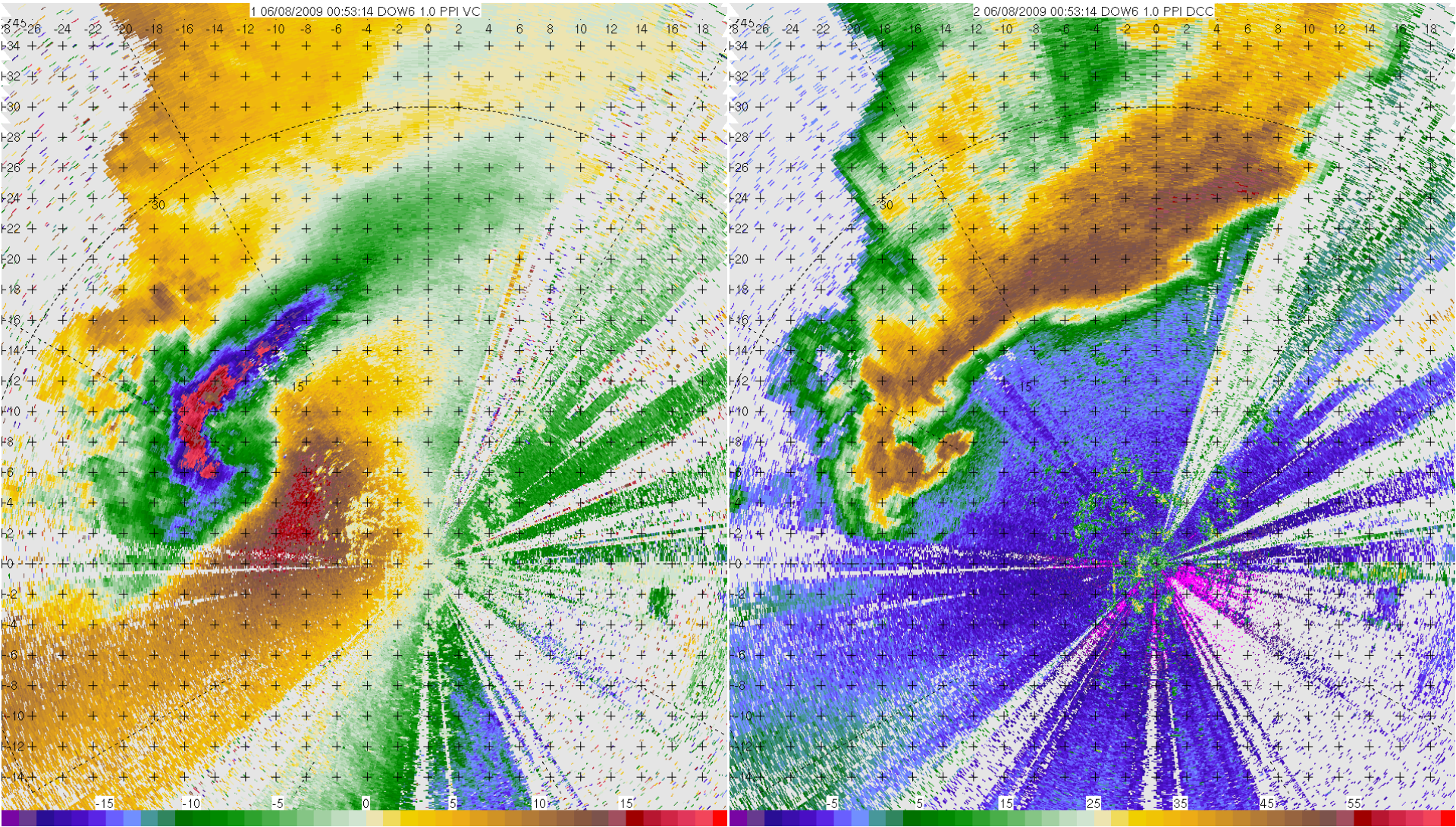


7 June deployment !st along MO river



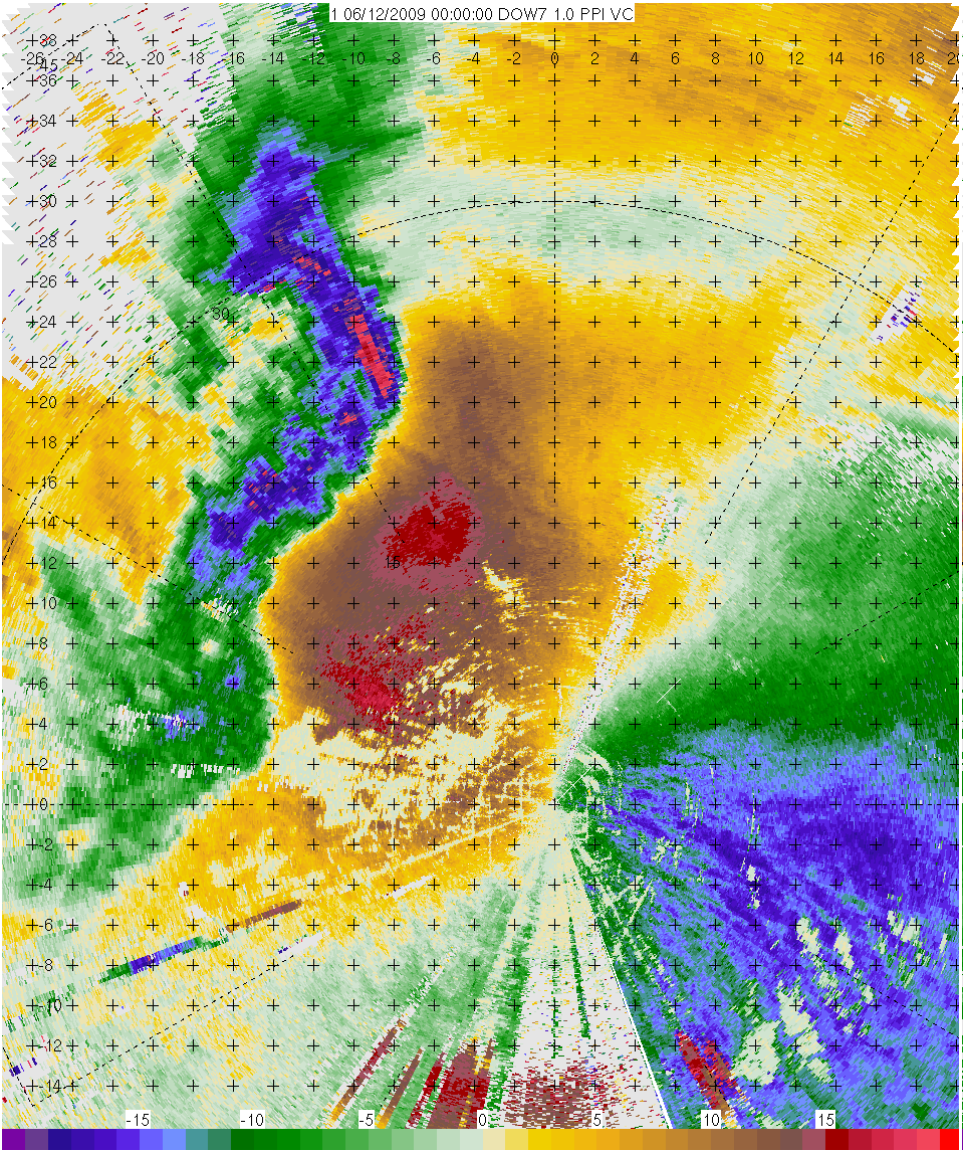


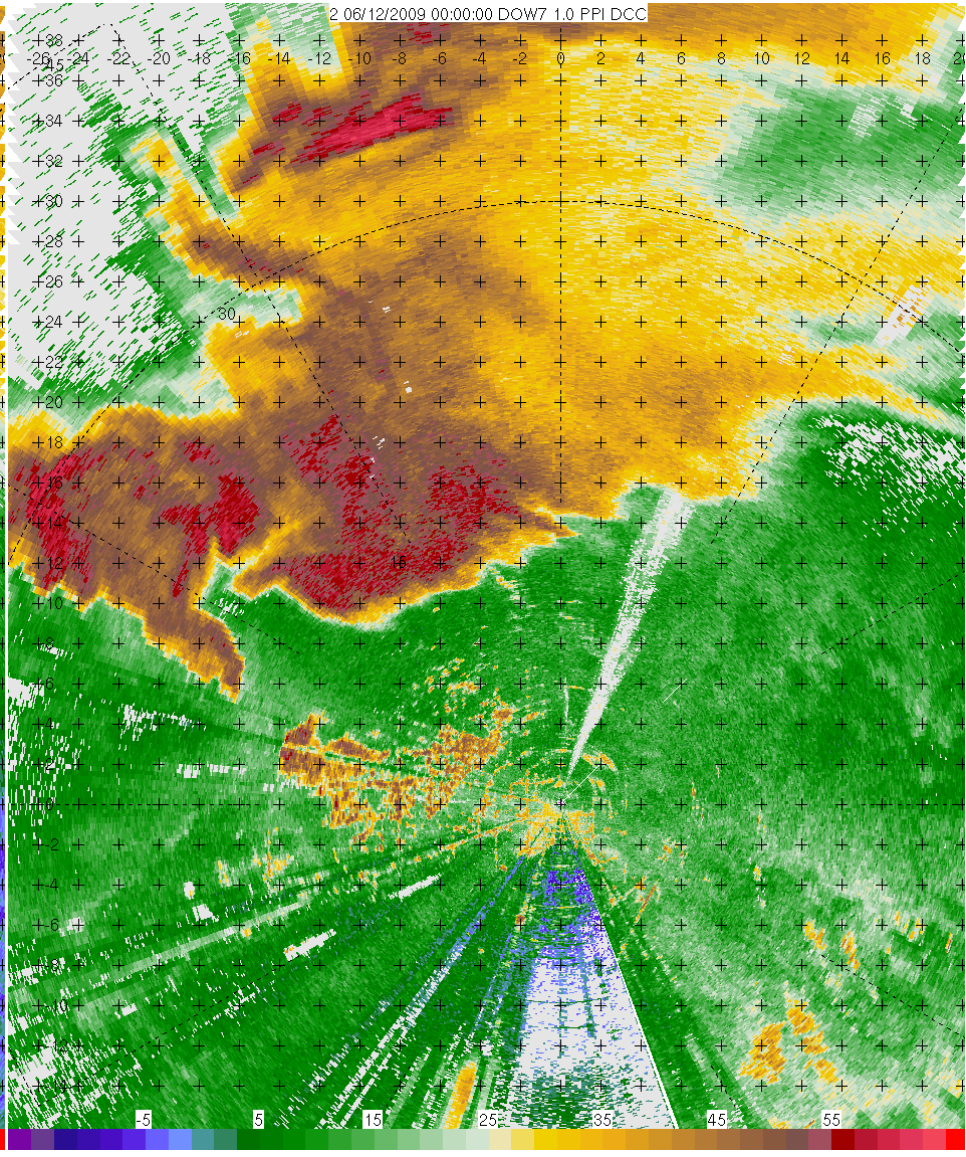
7 June deployment DOW6
deployment south of Maysville

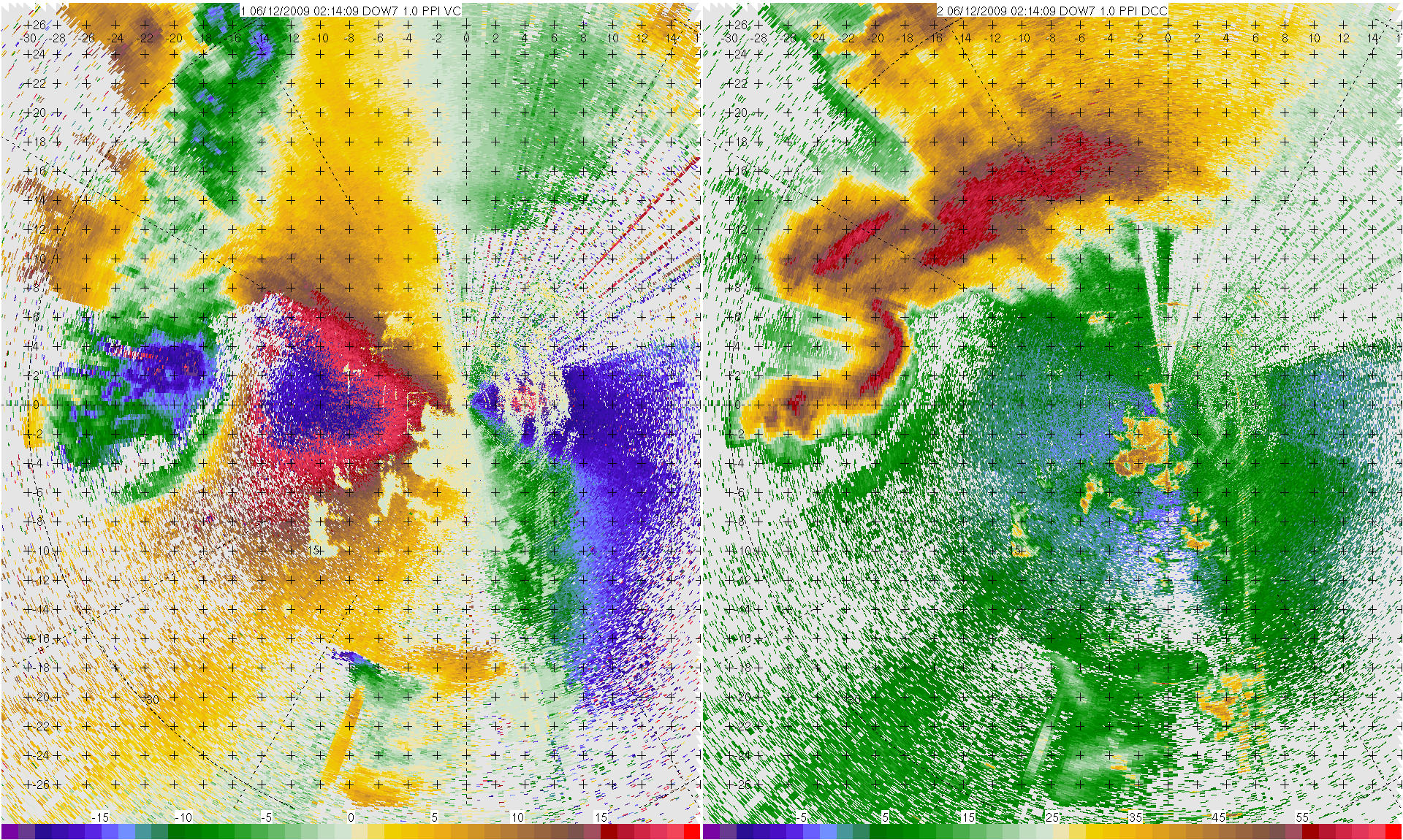


11 June

11 June La Junta, Colorado No Tornado





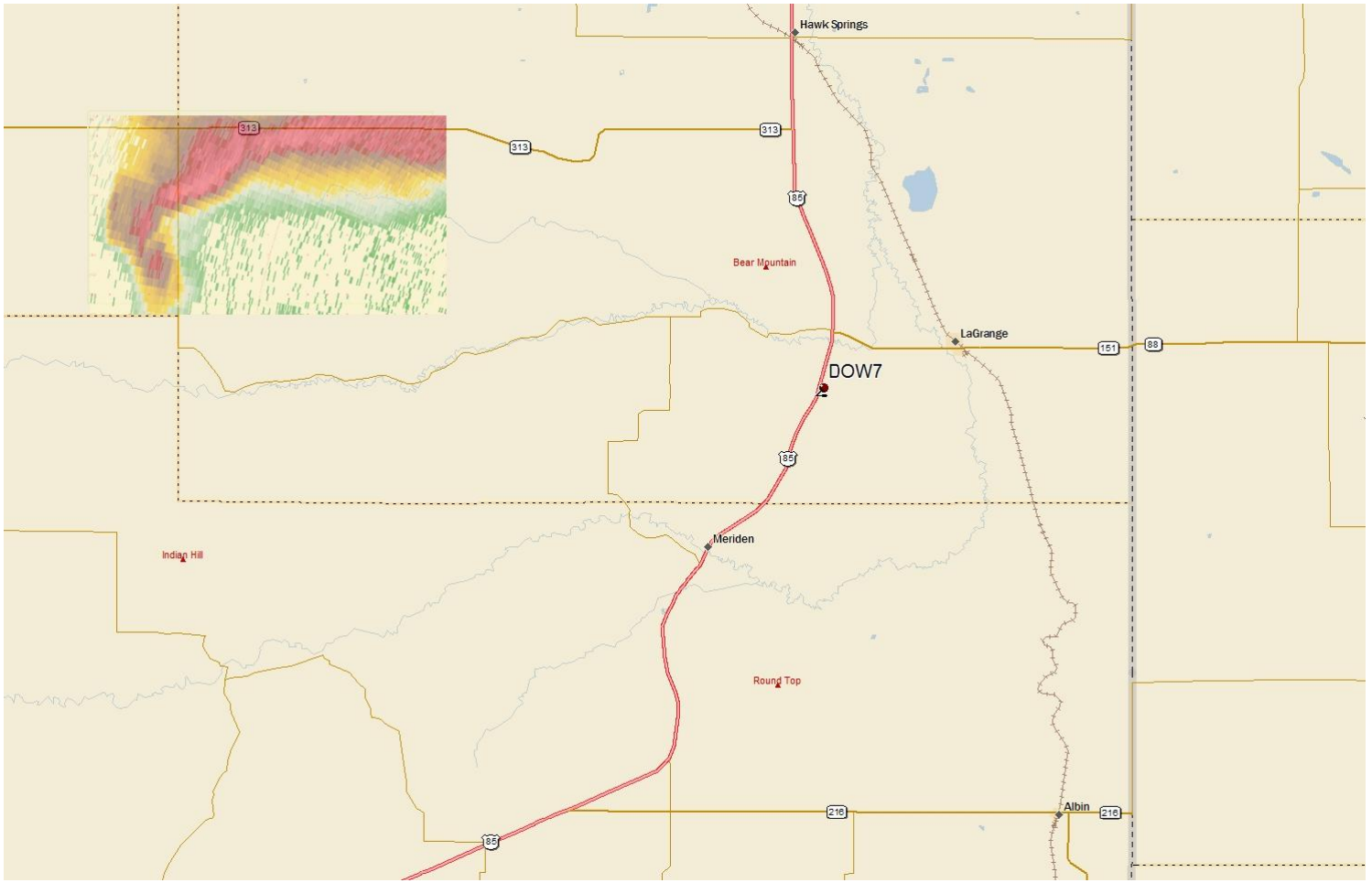

1 06/12/2009 02:14:09 DOW7 1.0 PPI VC
2 06/12/2009 02:14:09 DOW7 1.0 PPI DCC

26 May

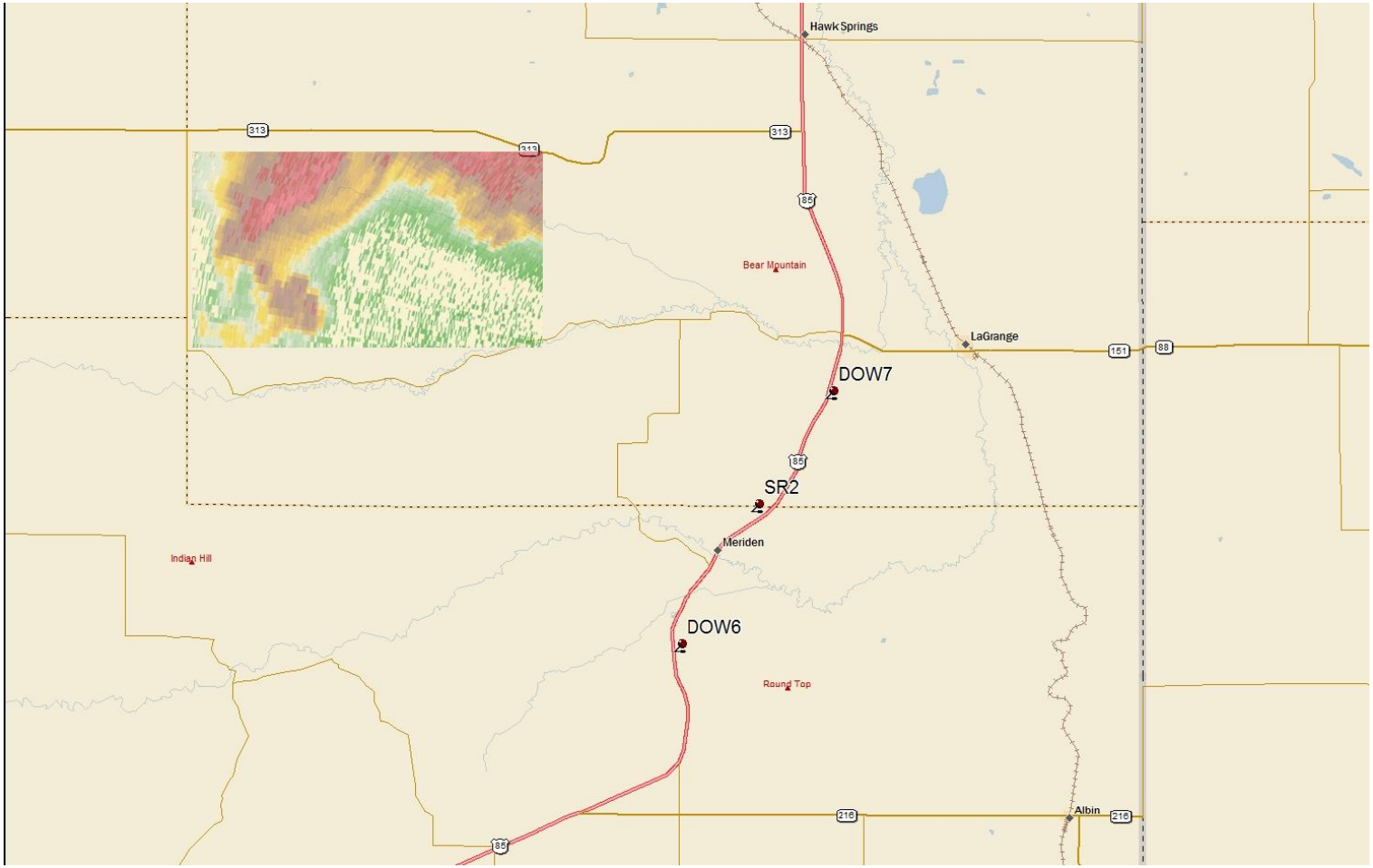
Got data. No time now.

05 June

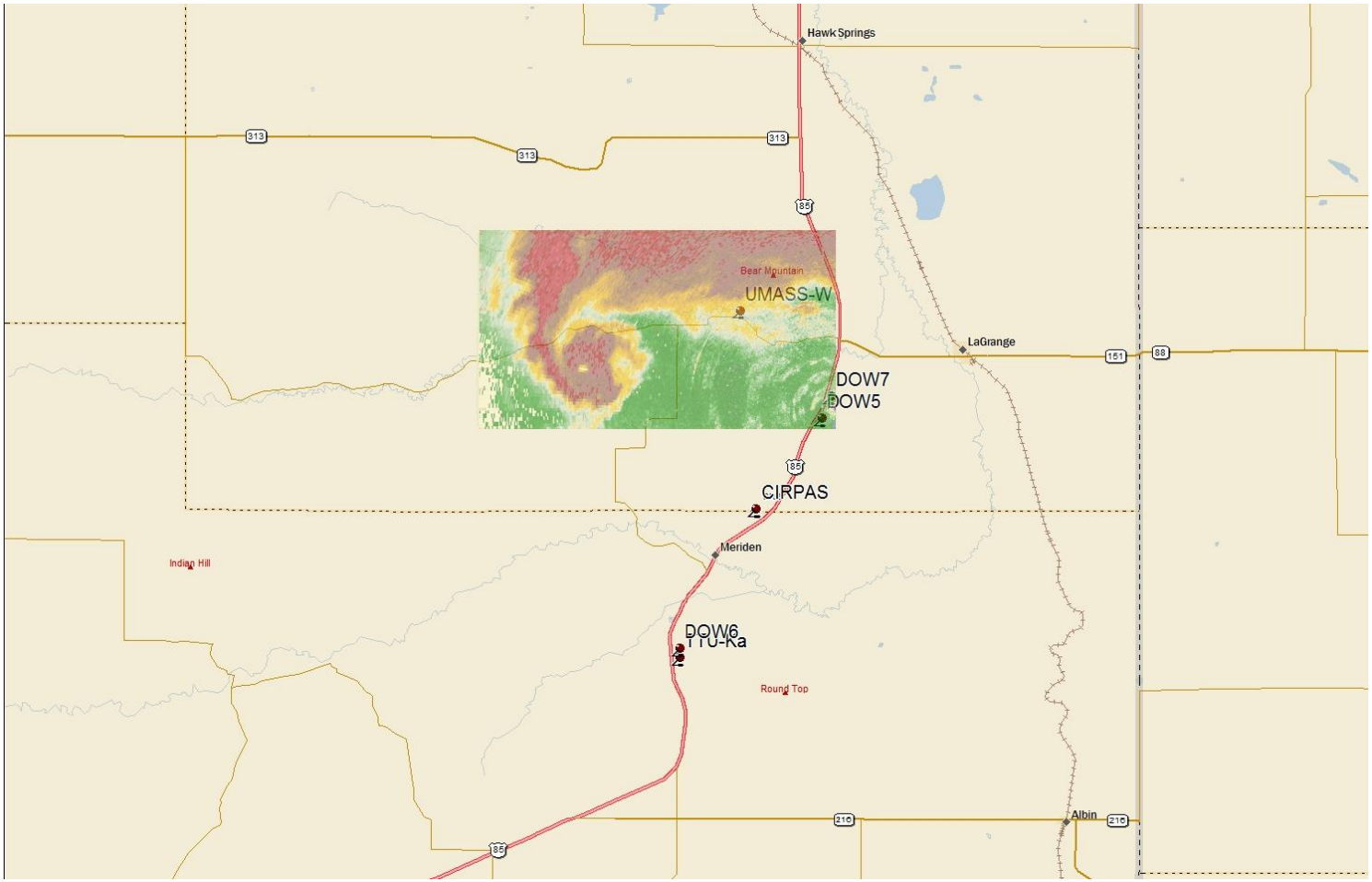
2130z – June 5 2009 – SE WY



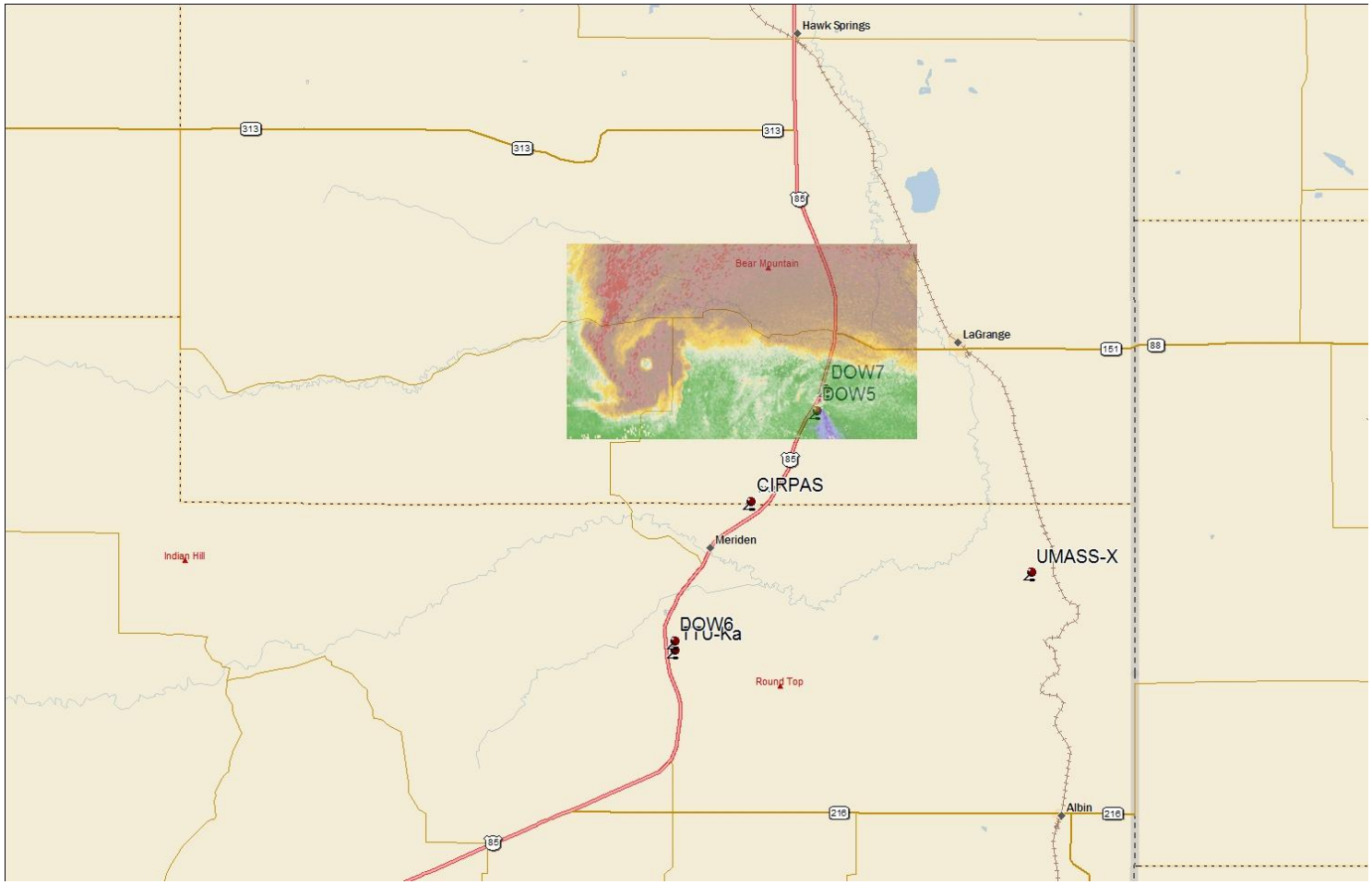
2140z – June 5 2009 – SE WY



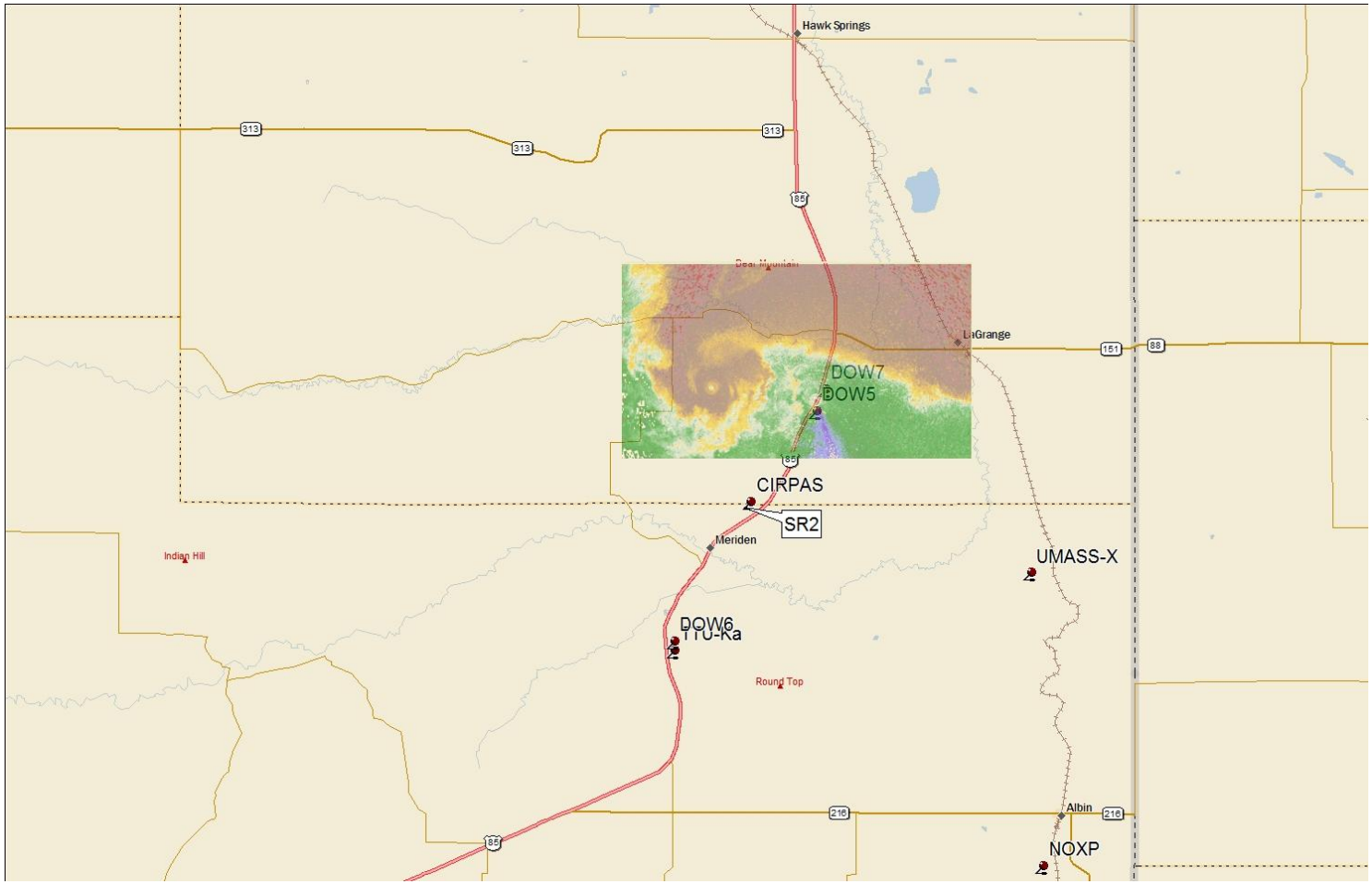
2203z – June 5 2009 – SE WY



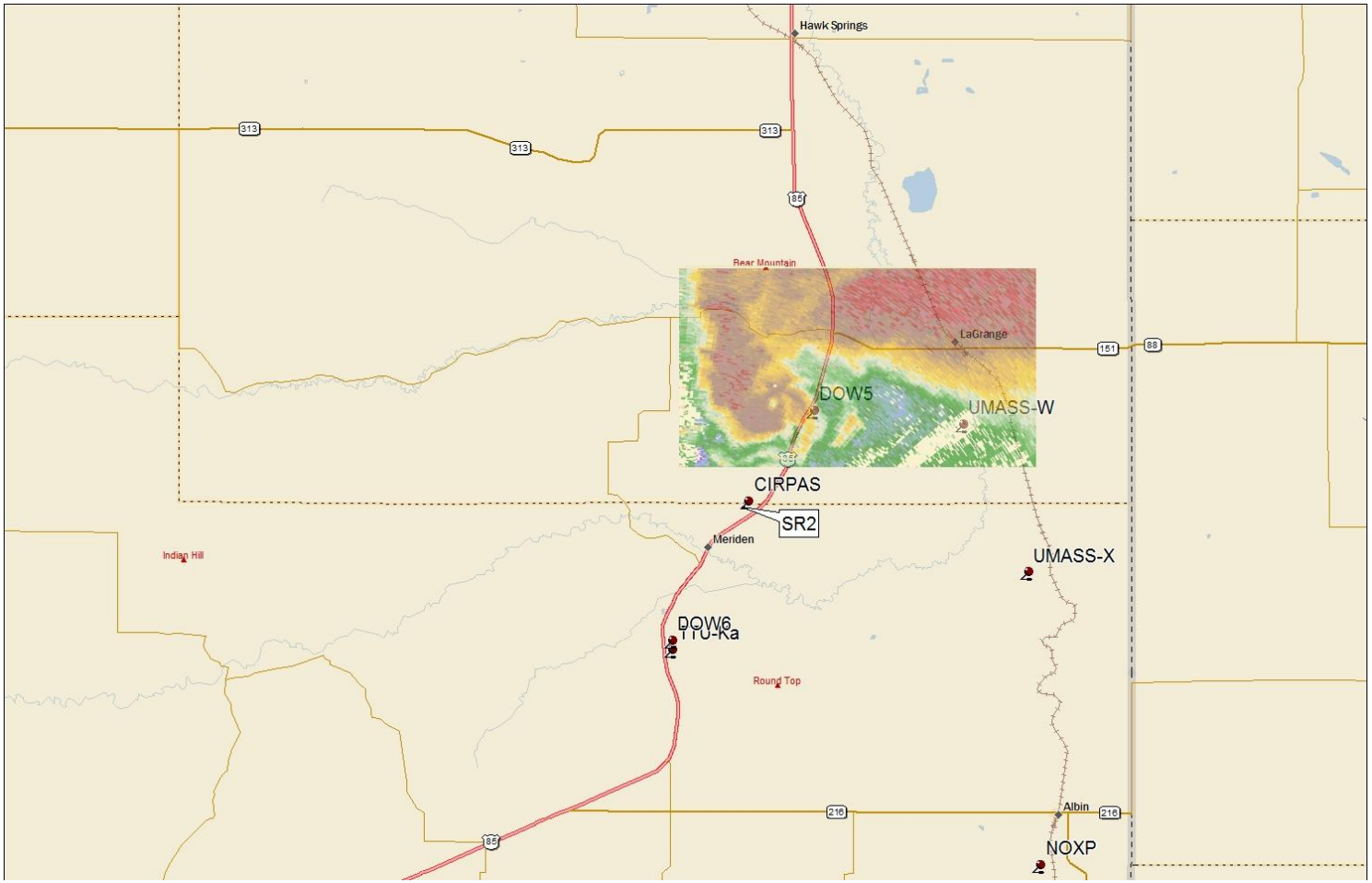
2209z – June 5 2009 – SE WY



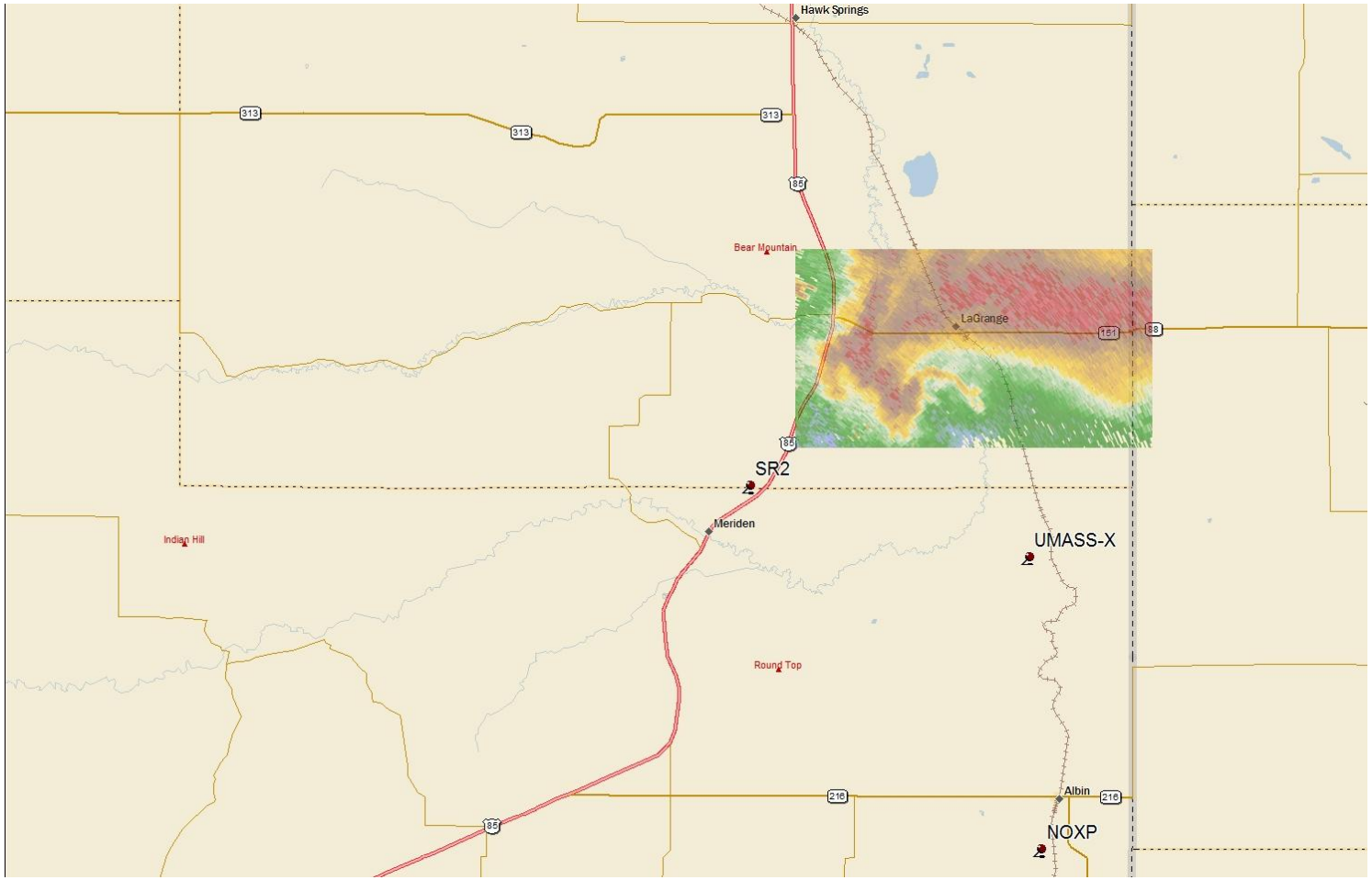
2216z – June 5 2009 – SE WY



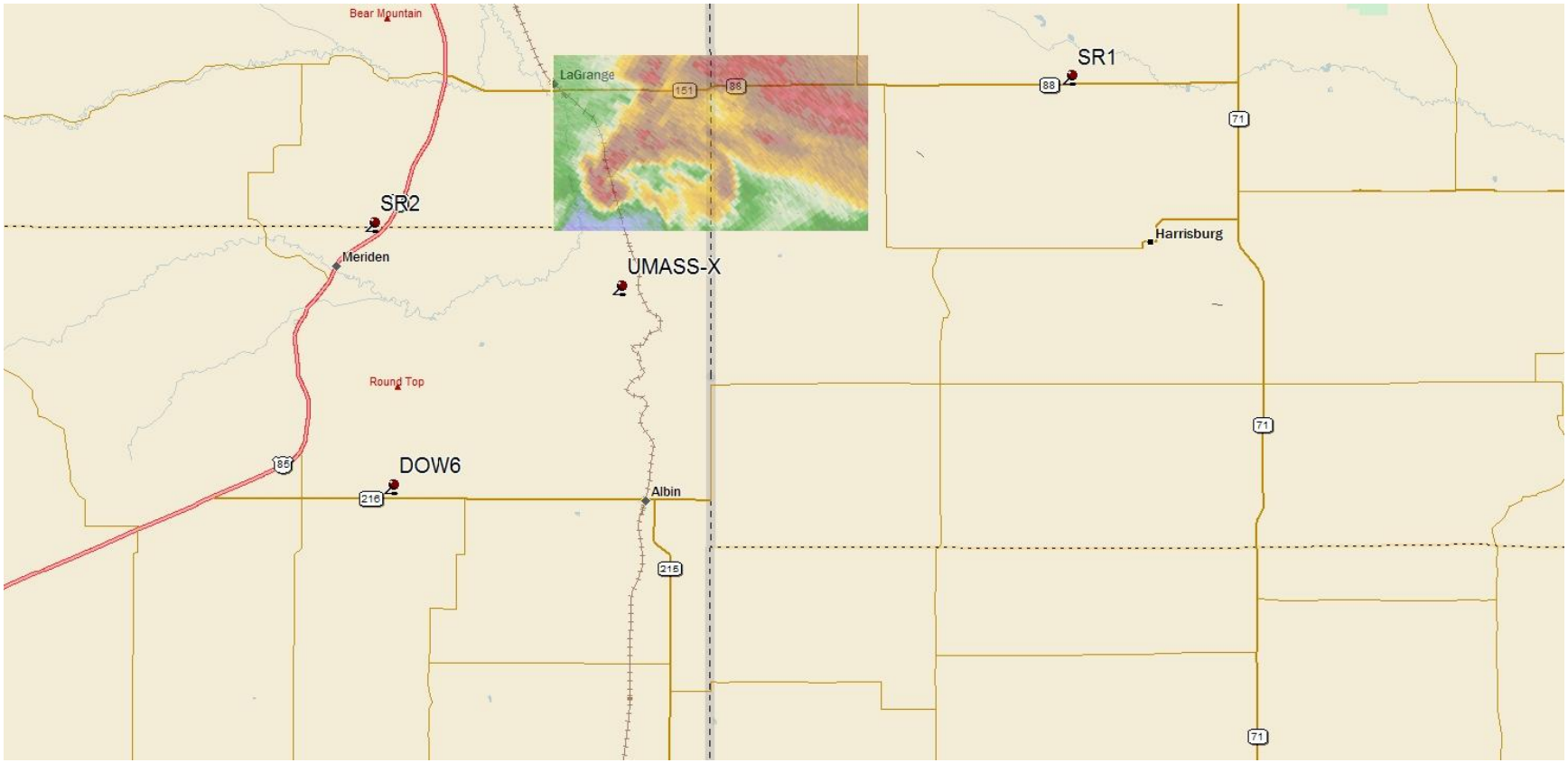
2221z – June 5 2009 – SE WY



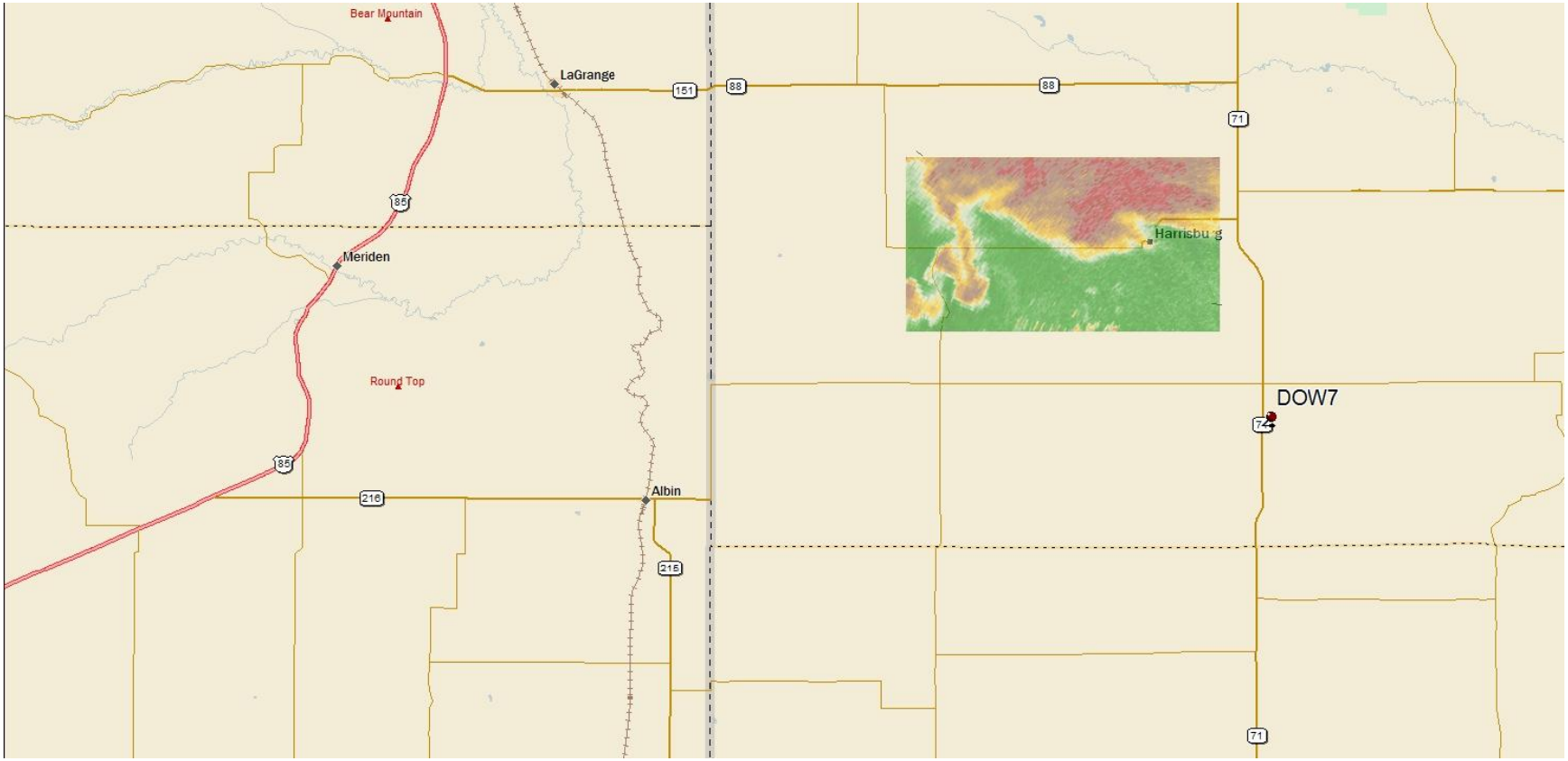
2234z – June 5 2009 – SE WY



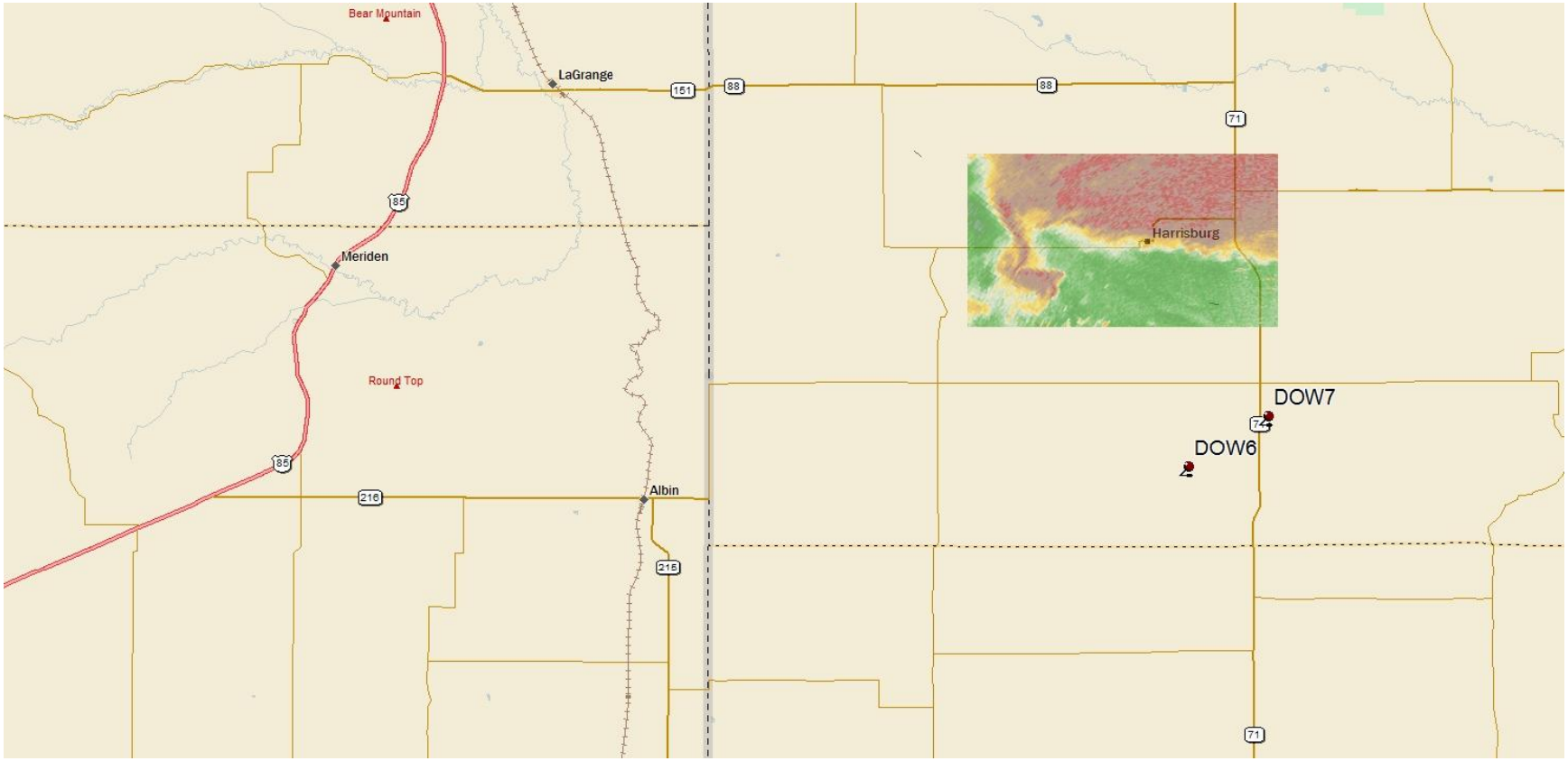
2247z – June 5 2009 – SE WY



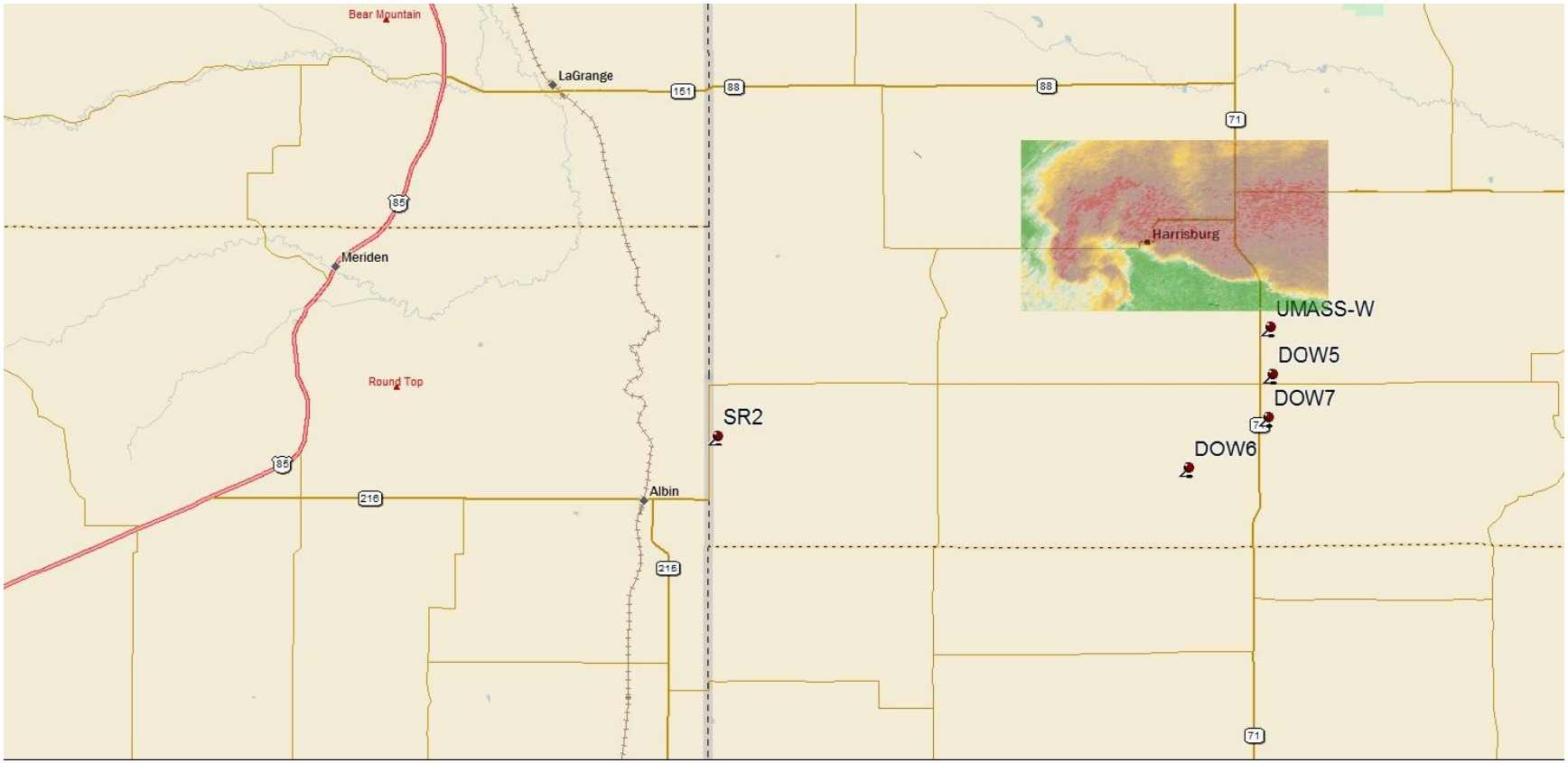
2321z – June 5 2009 – NW NE



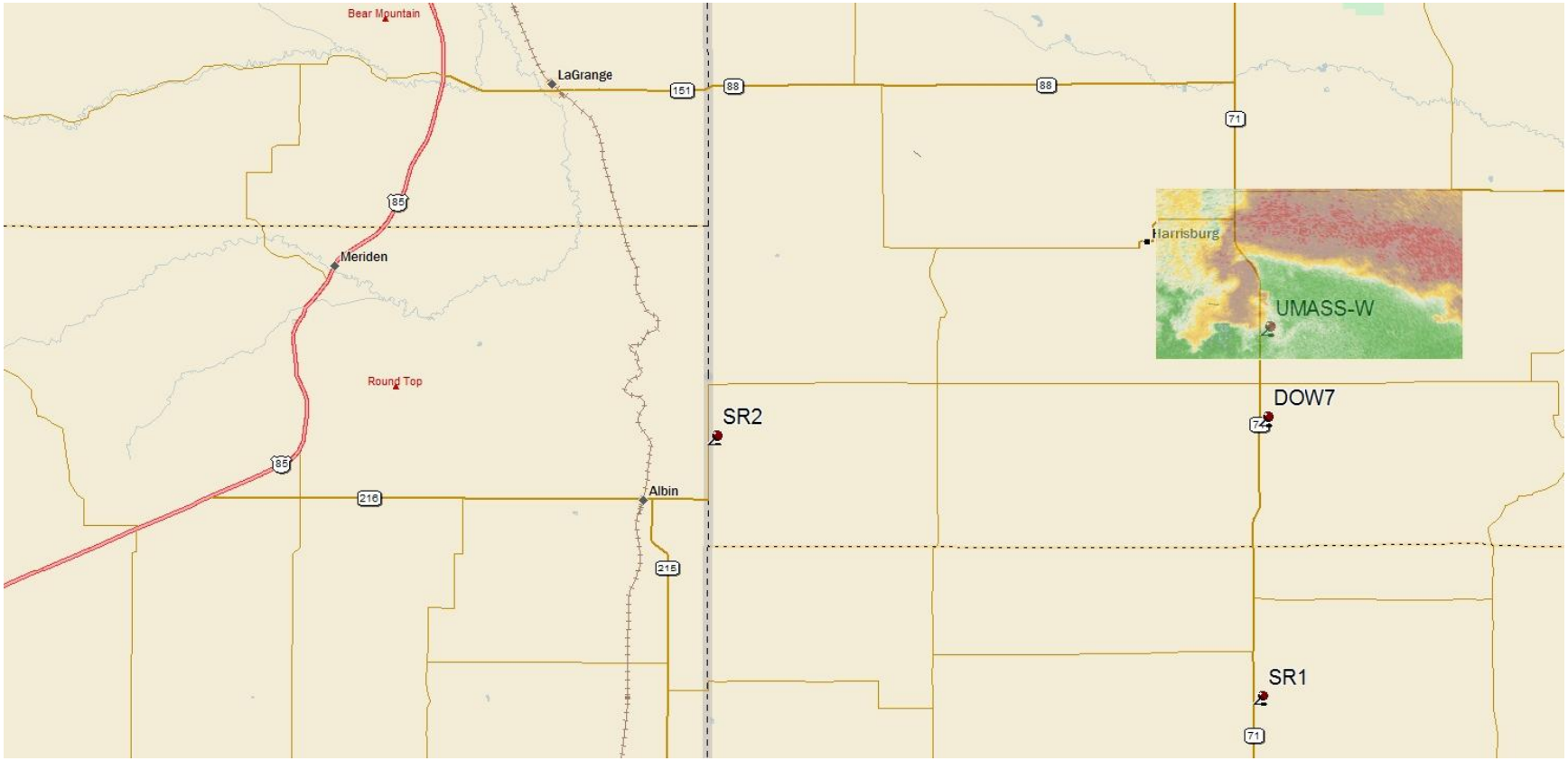
2332z June 5 2009 – NW NE



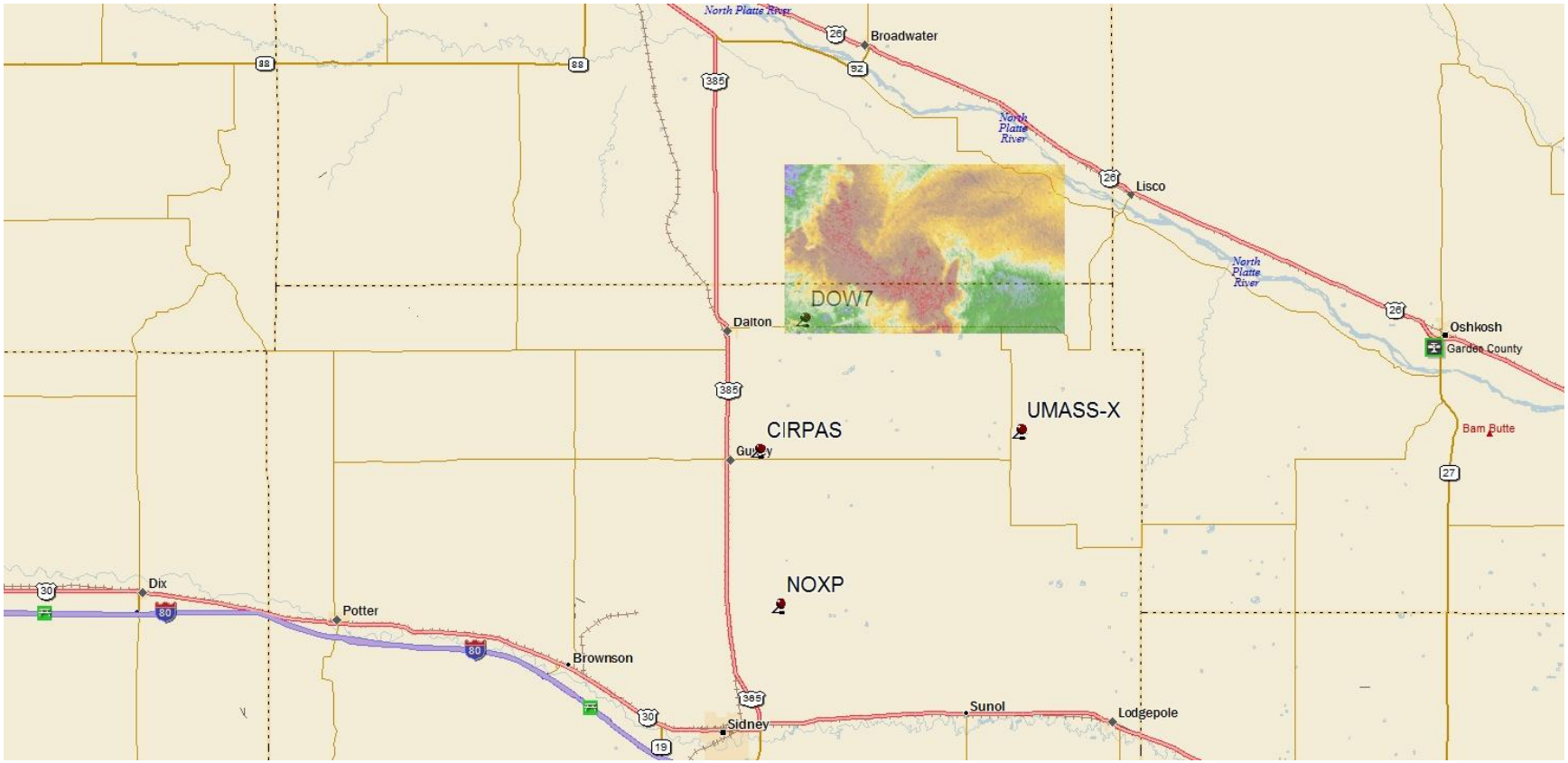
2341z – June 5 2009 – NW NE



0001z – June 6 2009 – NW NE



0156z – June 6 2009 – NW NE



05 June Tornado/Meso Track DOW Locations

DOW7 deployed 21:30
DOW6 deployed 21:40
Rapid-Scan DOW deployed 22:02

Single-Doppler 21:30-22:34

- 64 minutes
- 32 volumes 3-7 km deep
- 64 volumes 500 m deep

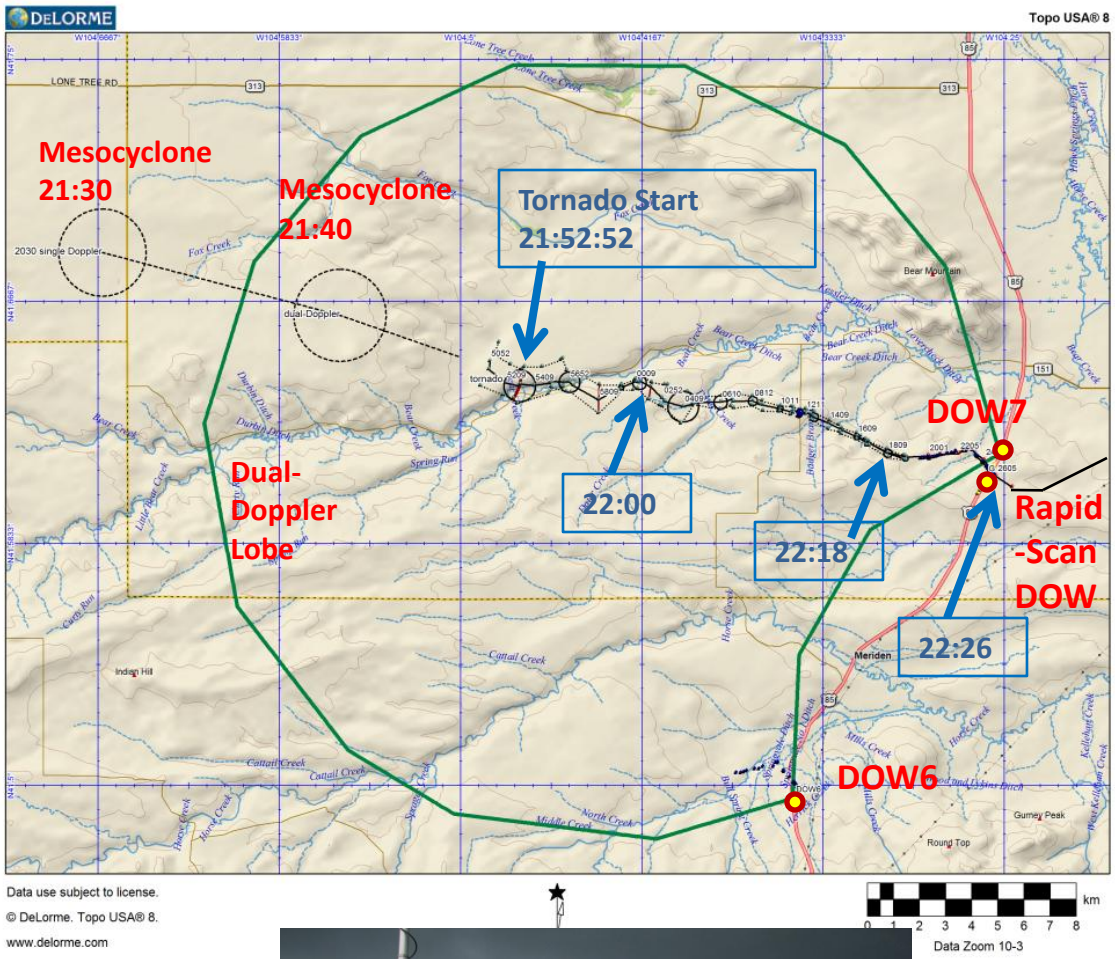
Dual-Doppler 21:40-22:19

- 40 minutes, 20 deep volumes
- 40 shallow volumes

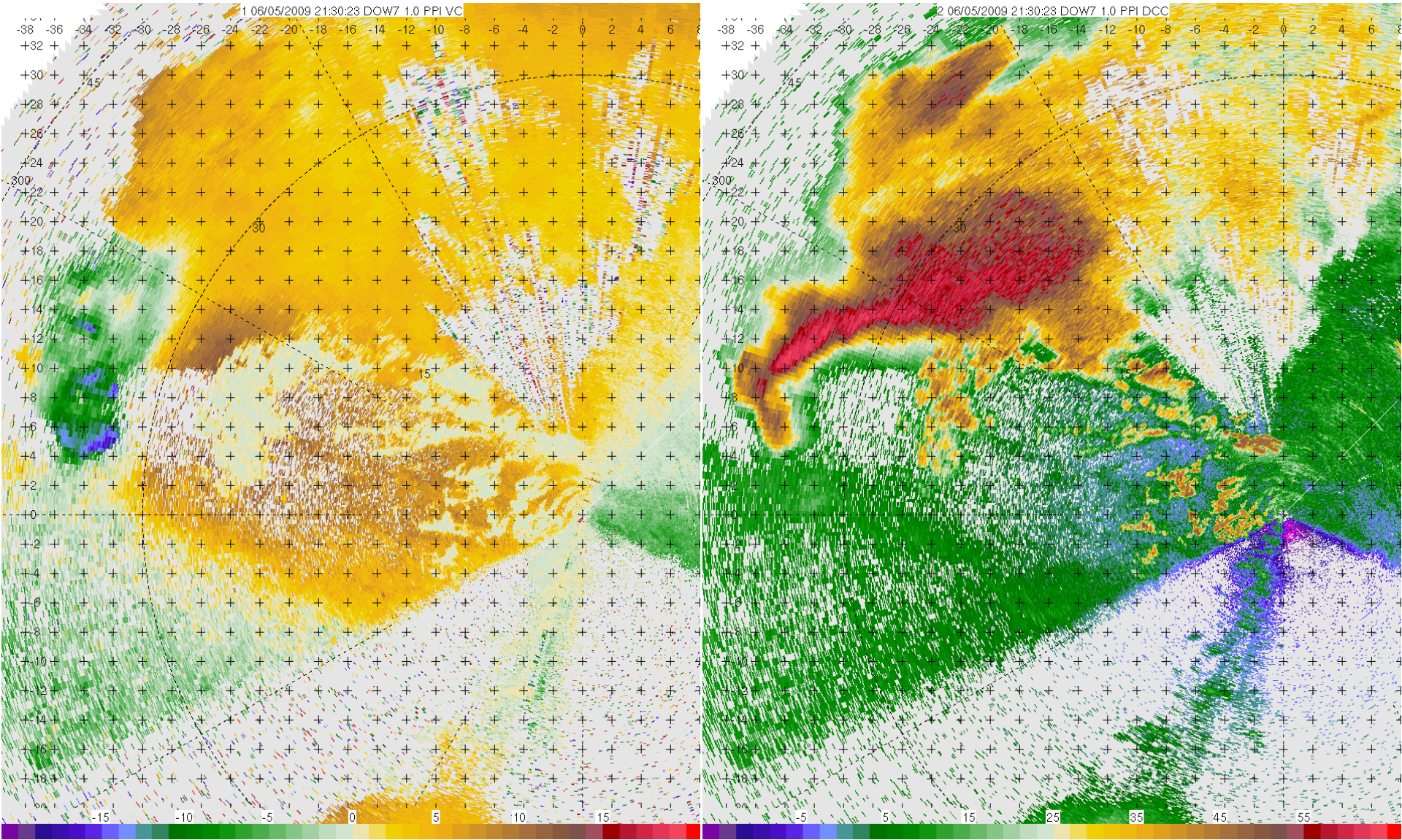
Rapid-Scan DOW:

- 30 minutes. 250 volumes @7 sec
- Closet tornado approach 400 m

Tornado locations, intensity, rmw's available.

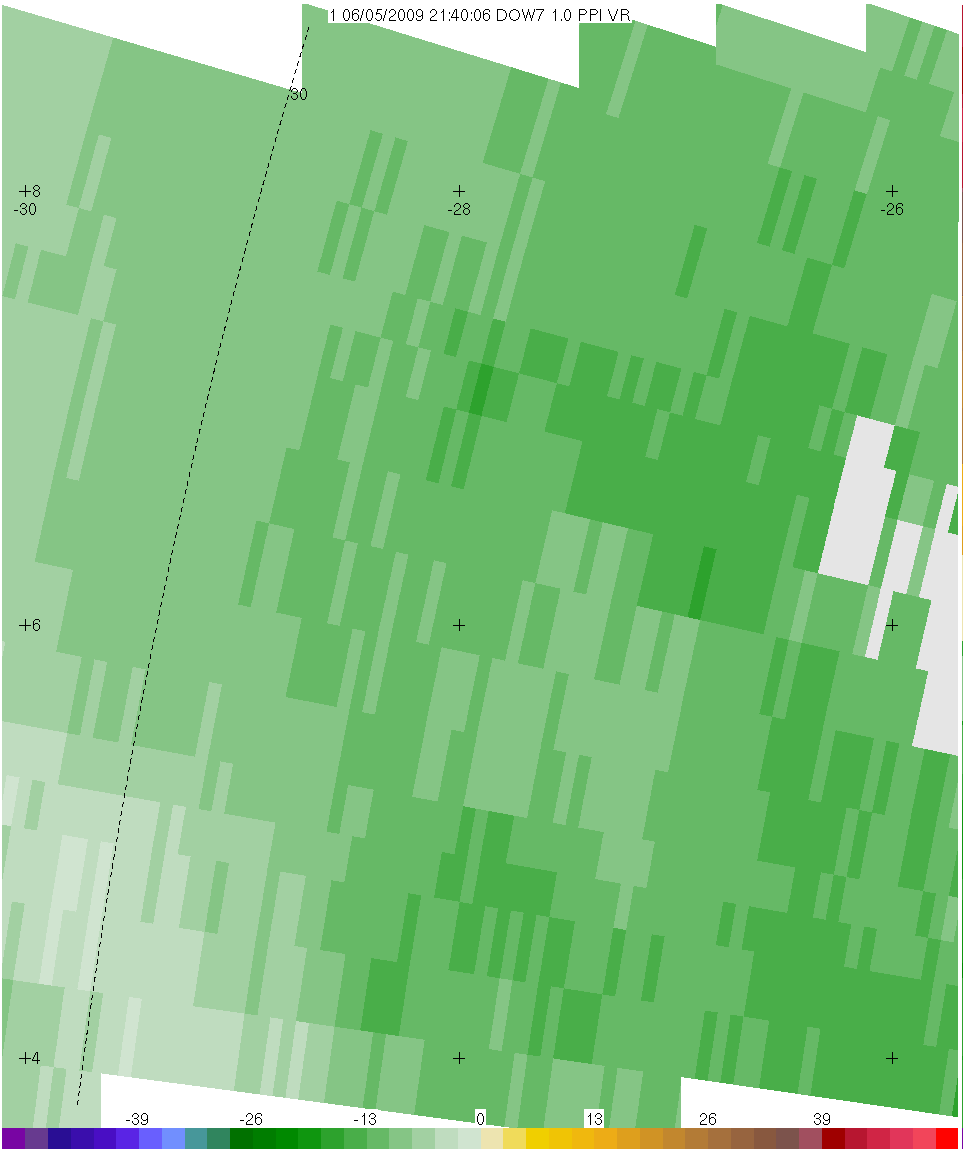


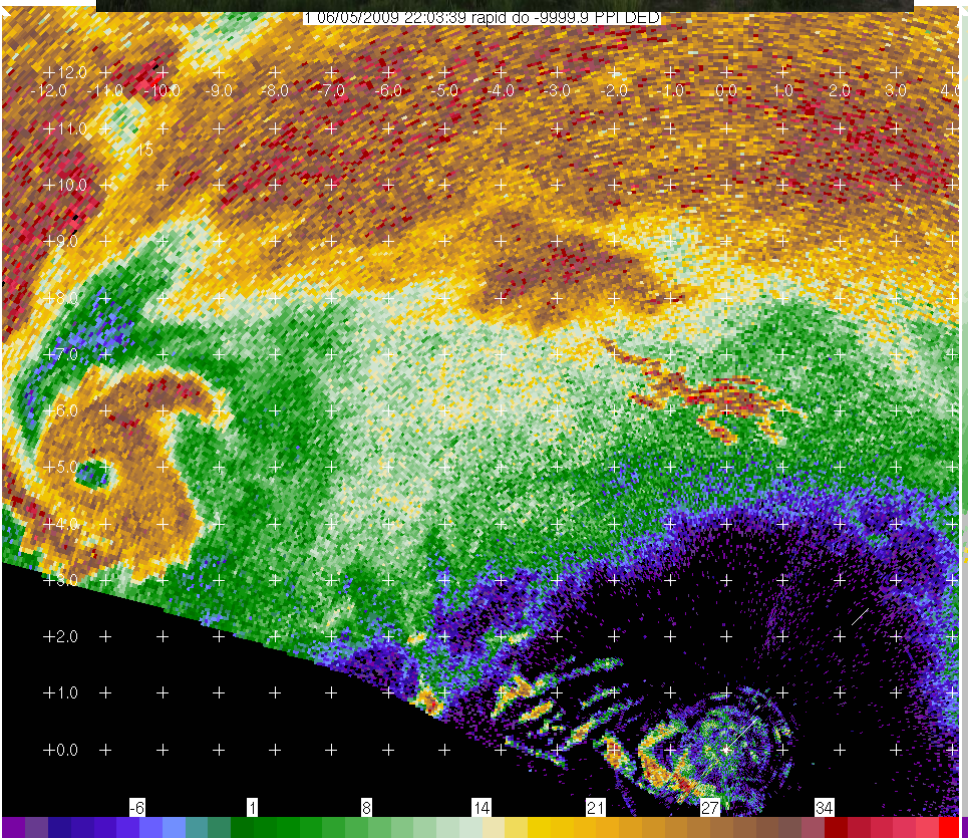
One minute animation of tornado: genesis through maturity

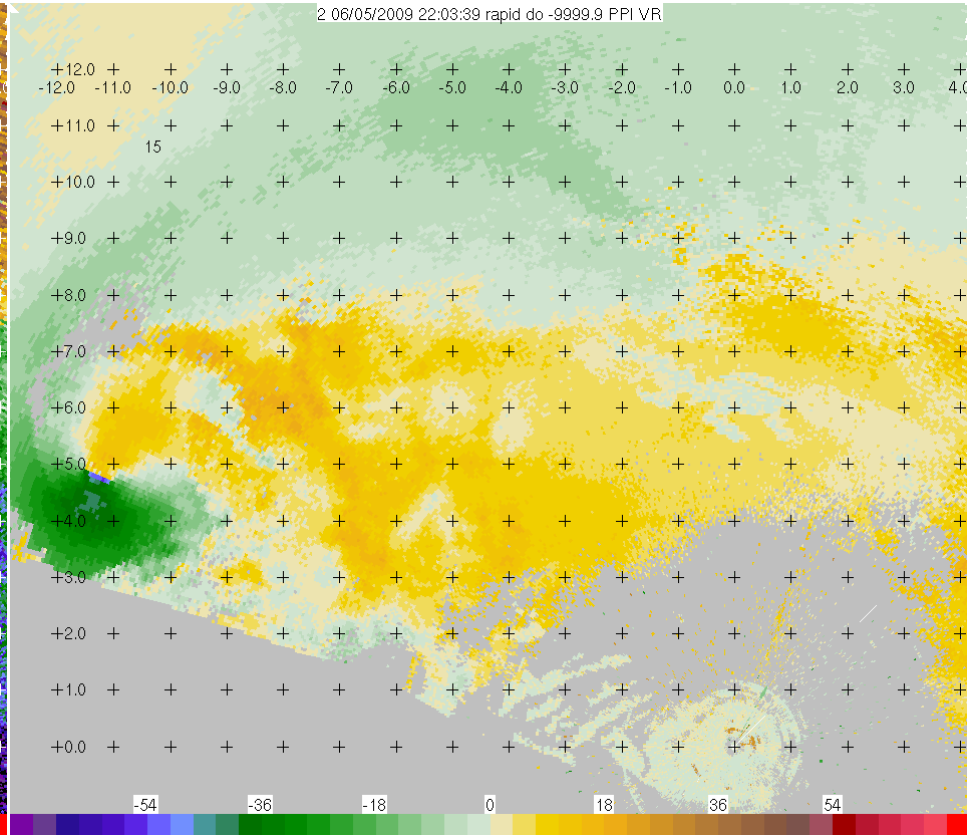


Full life of tornado measured: Genesis-23 minutes -- Death: Every 1 Minute

Range 20,000 m – 400 m

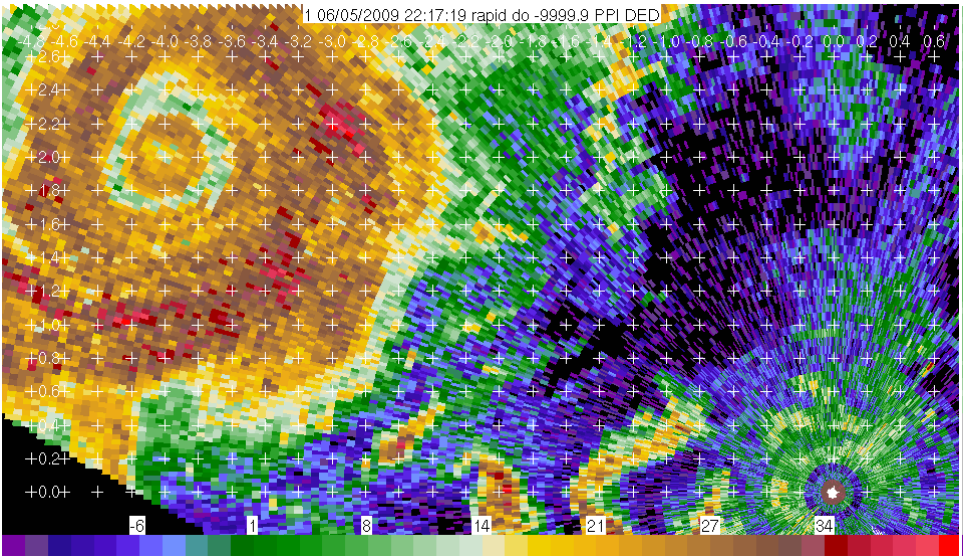


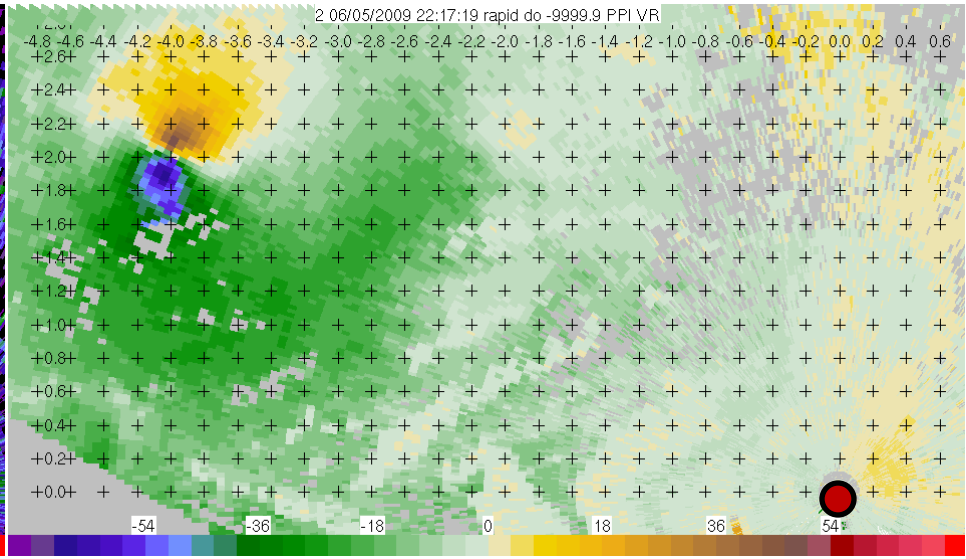

1 06/05/2009 22:03:39 rapid do -9999.9 PPI DBZ
-6
1
8
14
21
27
34

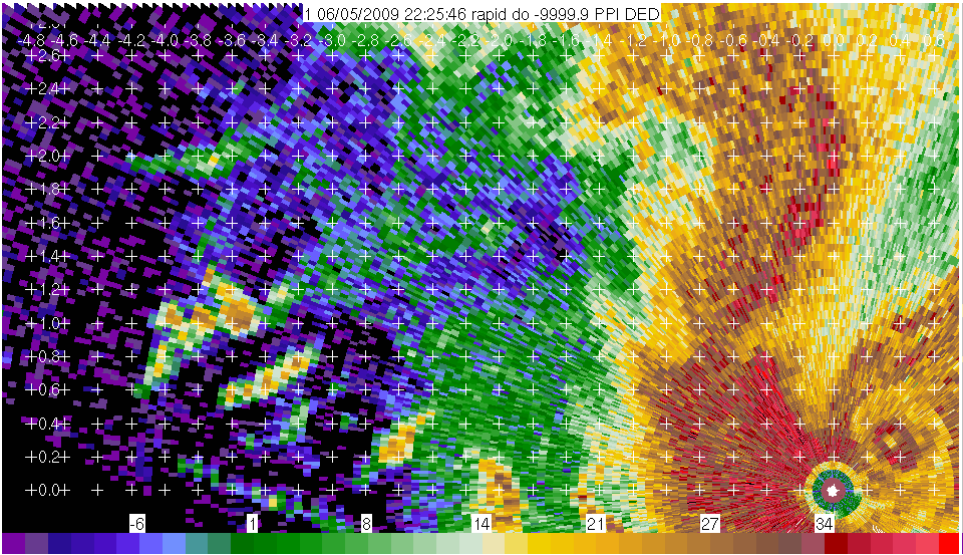

2 06/05/2009 22:03:39 rapid do -9999.9 PPI VR
-54
-36
-18
0
18
36
54

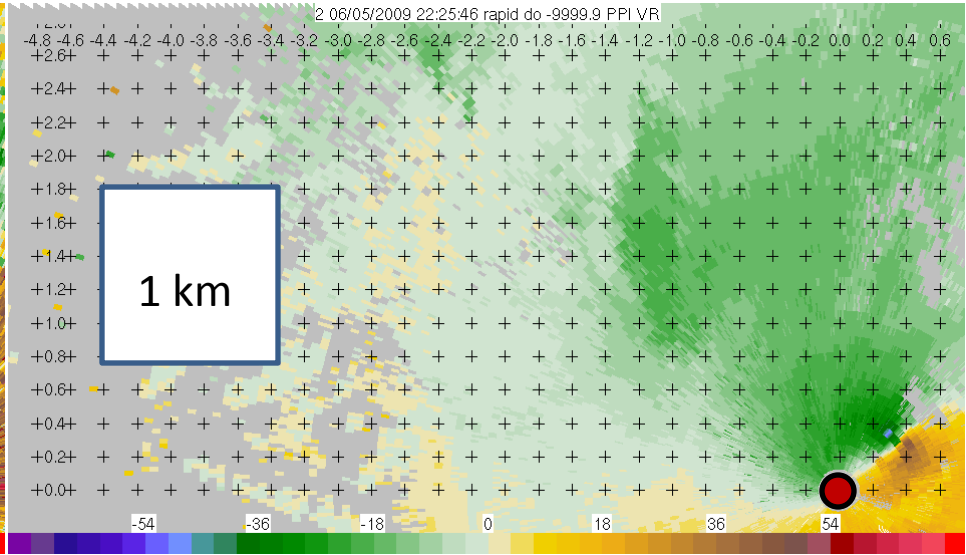
Tornado Approached 400 m from Rapid-Scan DOW

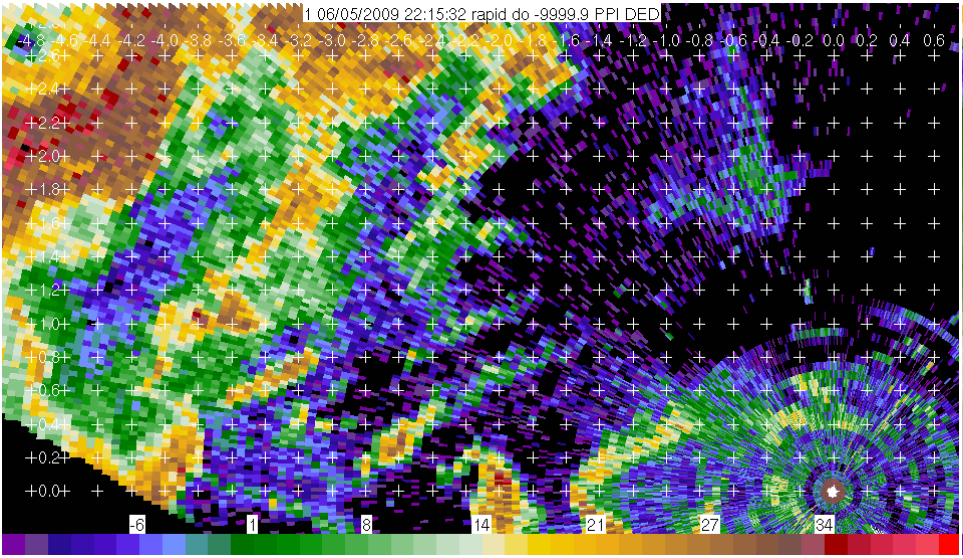
(beamwidth @400 m = 5 meters)

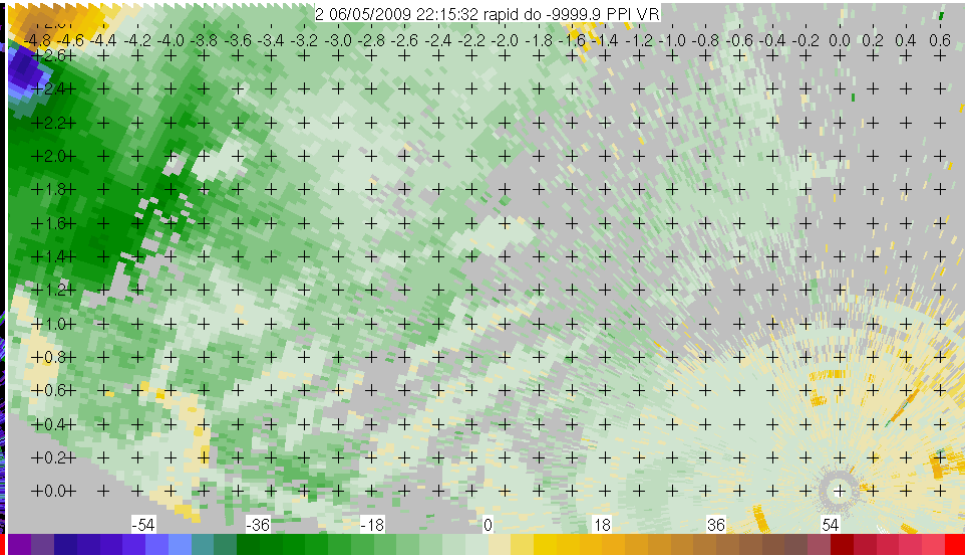








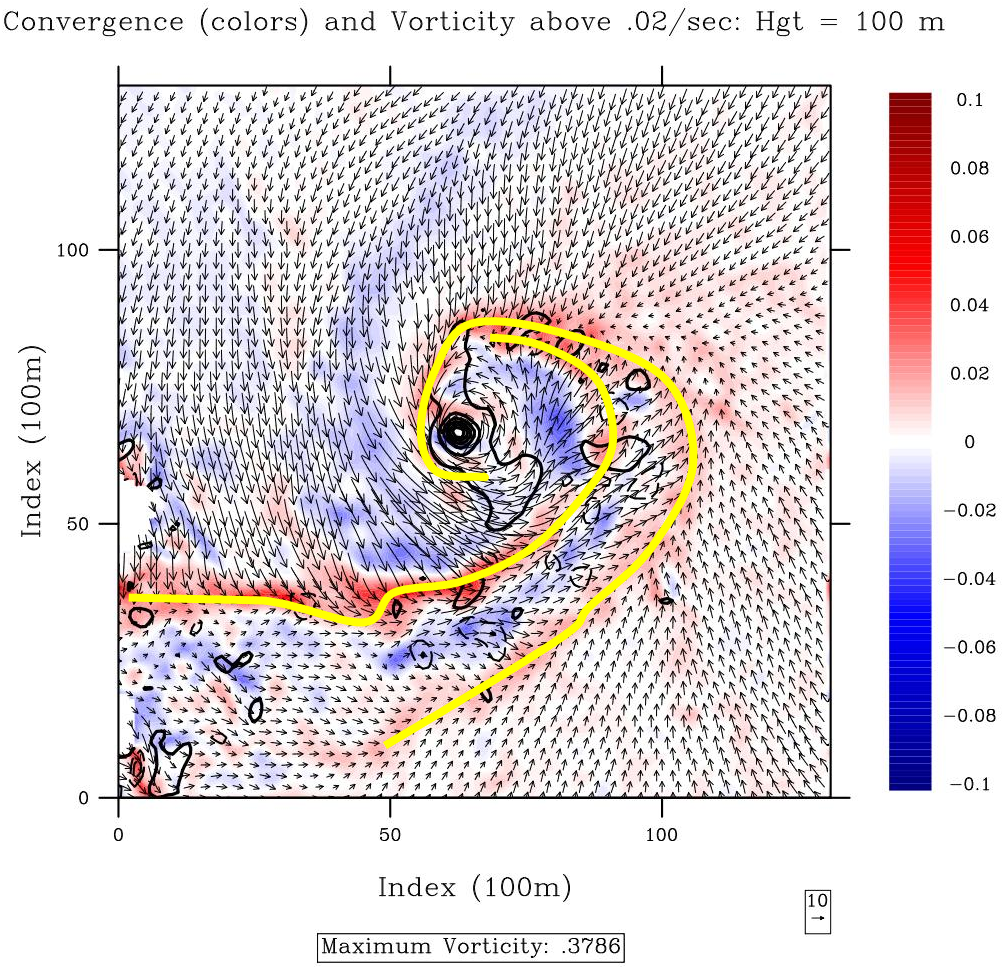

1 06/05/2009 22:15:32 rapid do -9999.9 PPI DED
-6
1
8
14
21
27
34

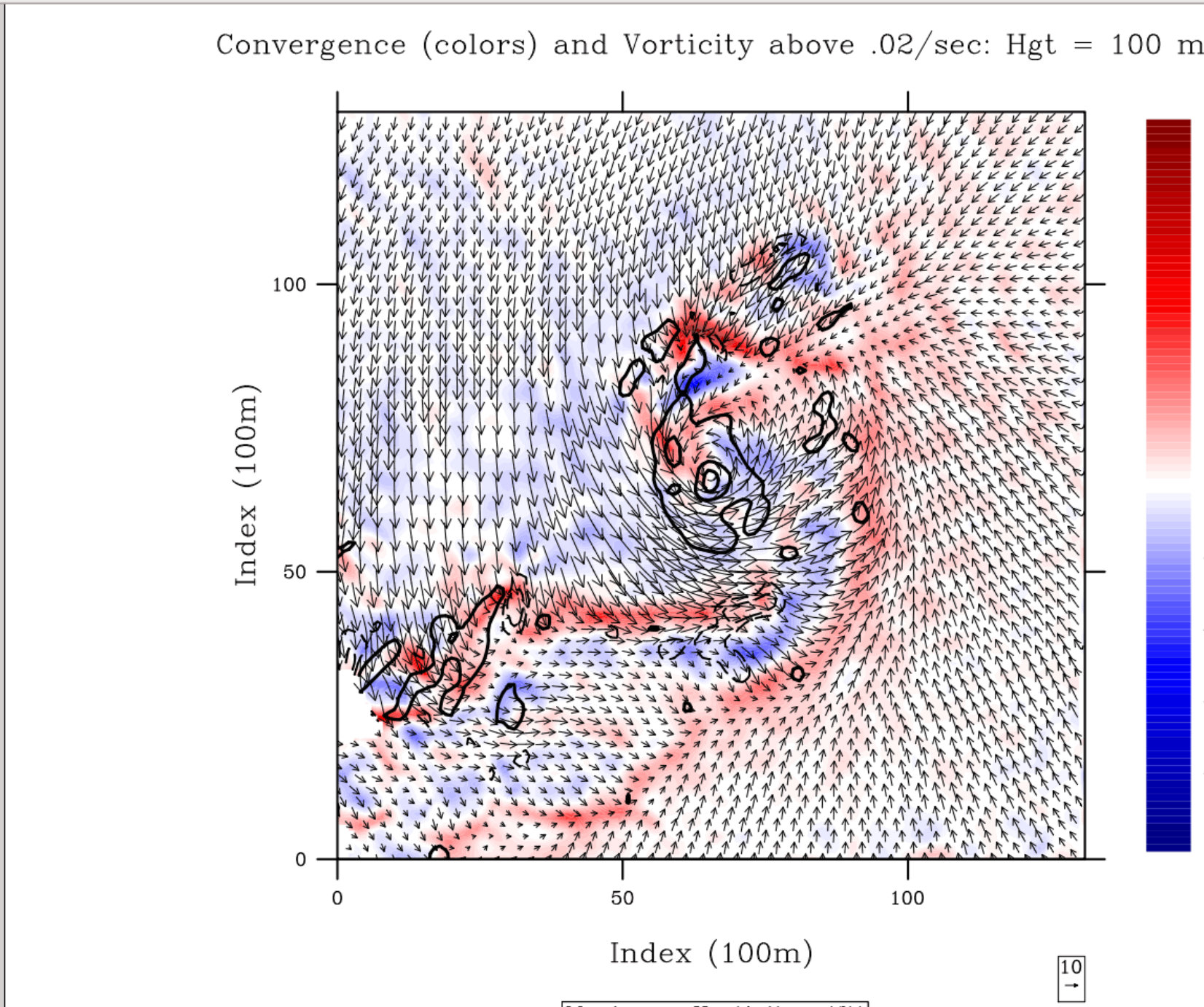

2 06/05/2009 22:15:32 rapid do -9999.9 PPI VR
-54
-36
-18
0
18
36
54

Data verified suitable for dual-Doppler

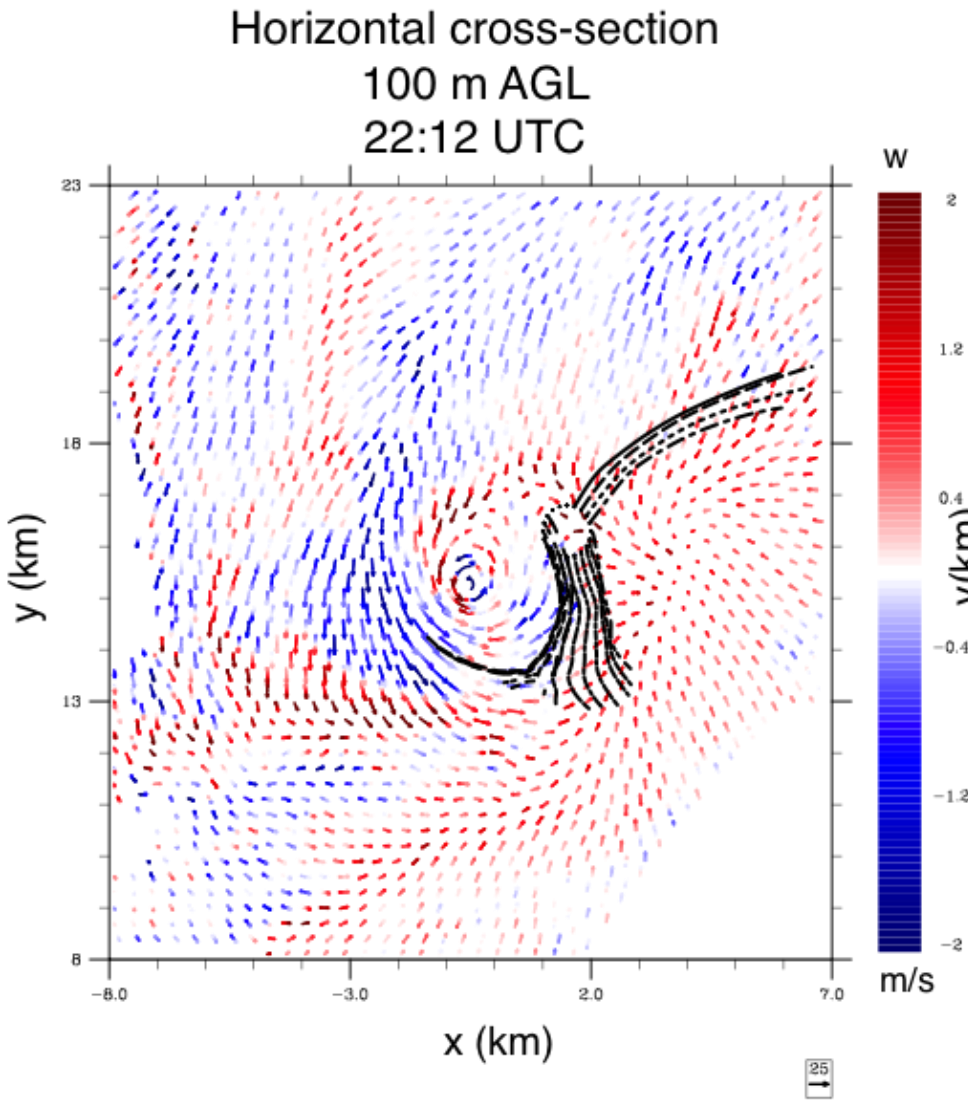
- Double Gust Front
- RFD with ~0 vorticity
- Trackable Vorticity Beads on Gust Front
- Peak RFD divergence several minutes before tornado intensification
- Two-Phase Tornado history, maybe 2 tornadoes?
- Cycloidal Motion

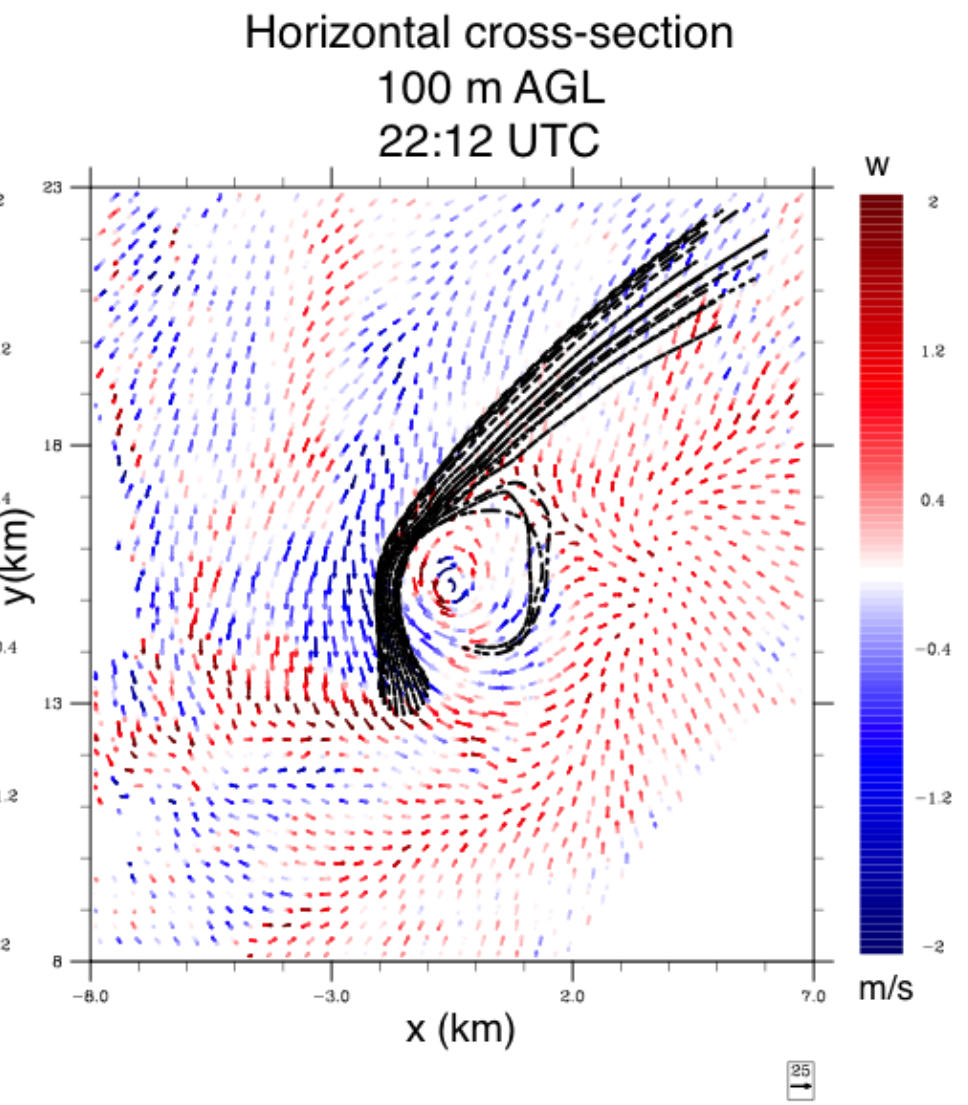
Convergence shaded
Vorticity contoured (0.02 s-1)

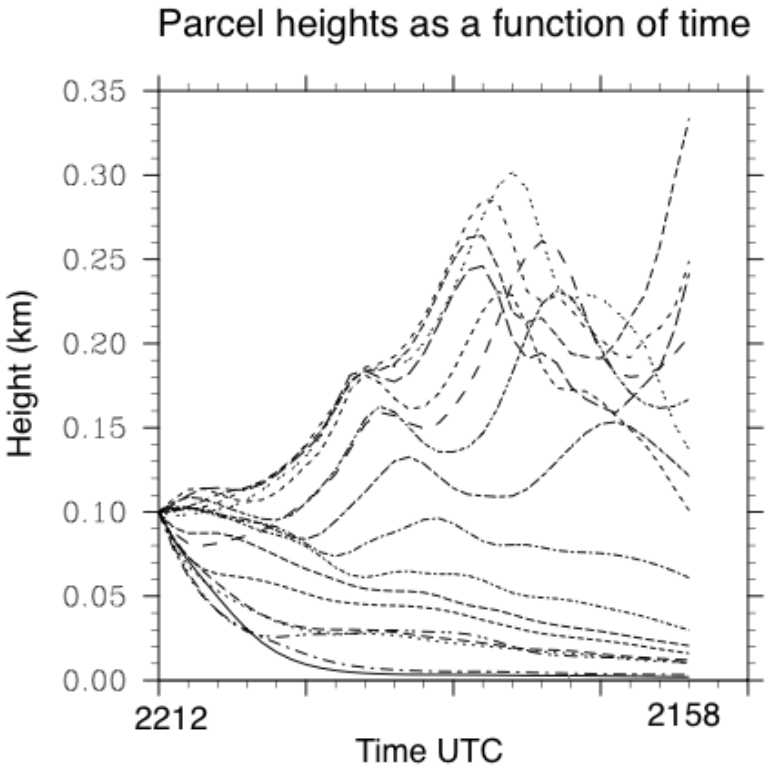


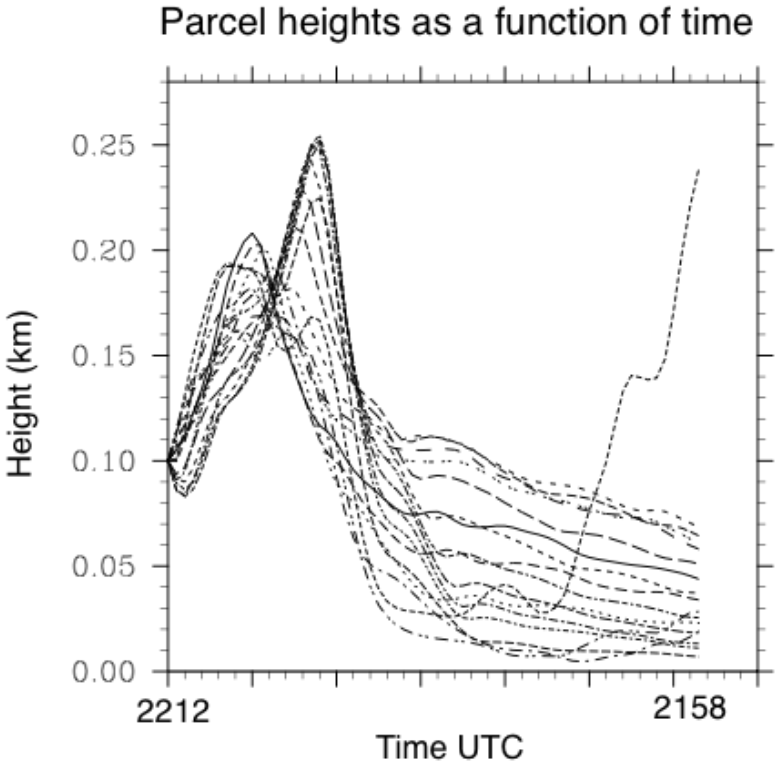

Convergence (colors) and Vorticity above .02/sec: Hgt = 100 m
Index (100m)
0
50
100
Index (100m)
0
50
100
10
Maximum Vorticity: .171

Backward trajectories from 22:12 to 21:58 UTC

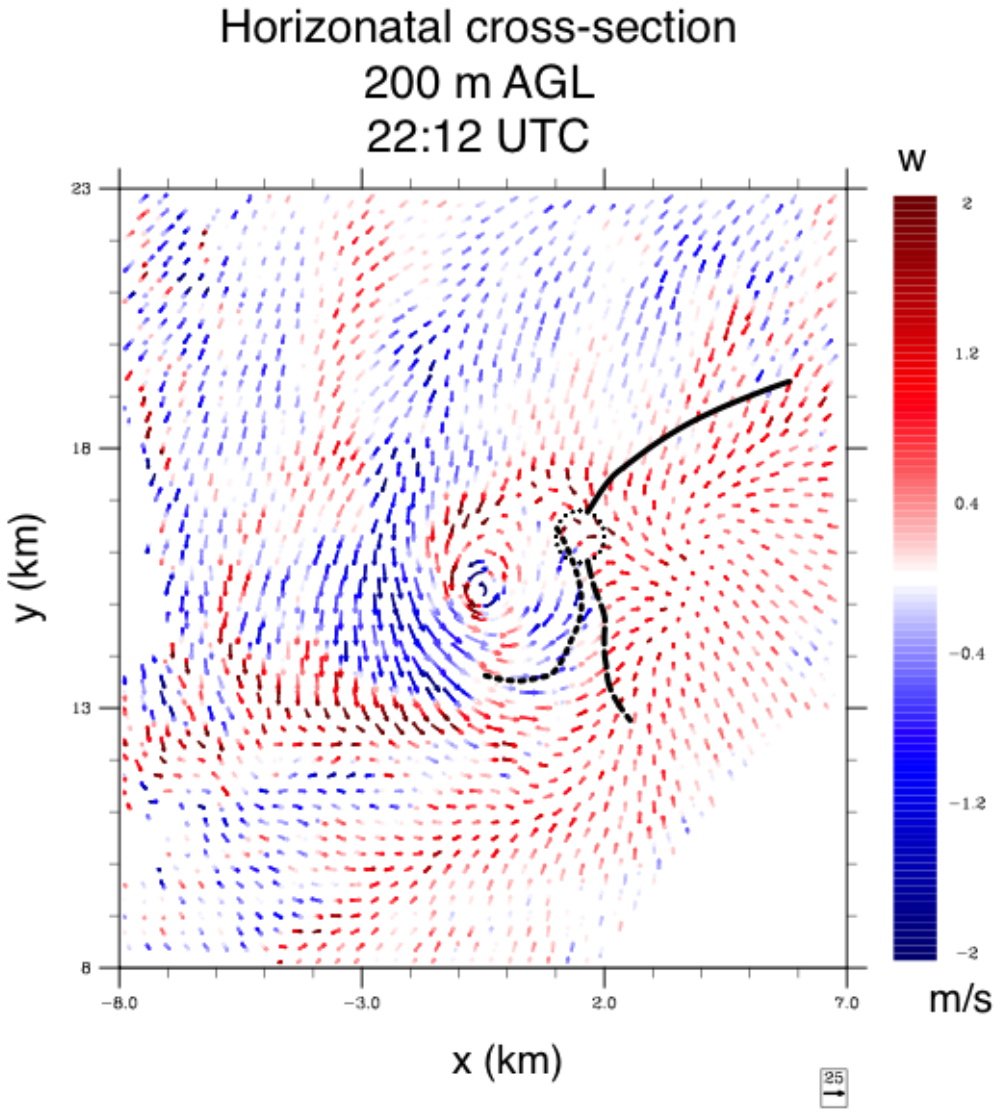


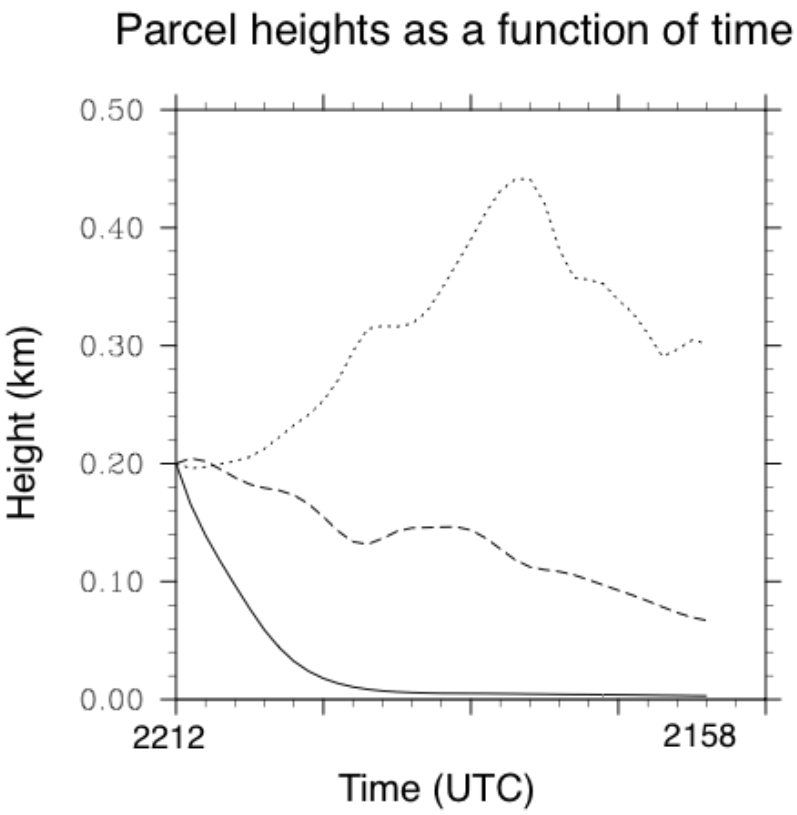



Parcel heights as a function of time
Height (km)
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
2212
2158
Time UTC

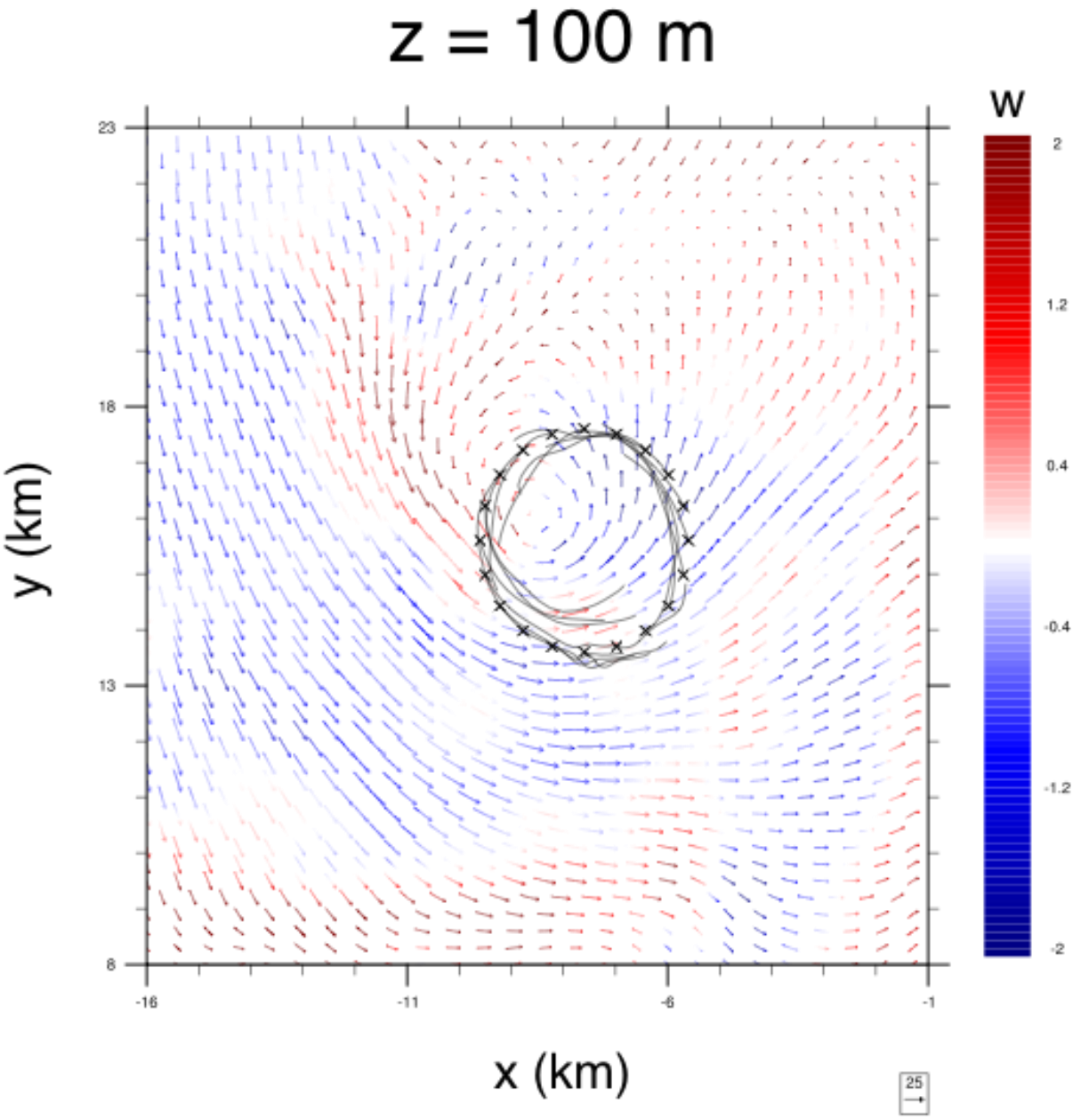

Parcel heights as a function of time
Height (km)
0.25
0.20
0.15
0.10
0.05
0.00
2212
2158
Time UTC

Parcel properties as a function of source region





Some Trajectories suggest a confined vortex



VORTEX2-2009 Low Level Winds Mission Failed

On 05 June, DOWs focused 100% on DD Mission

DOWs too distant from TIV @2211:

Lowest sweeps 54-144 m AGL @TIV
Above corner flow and wind max

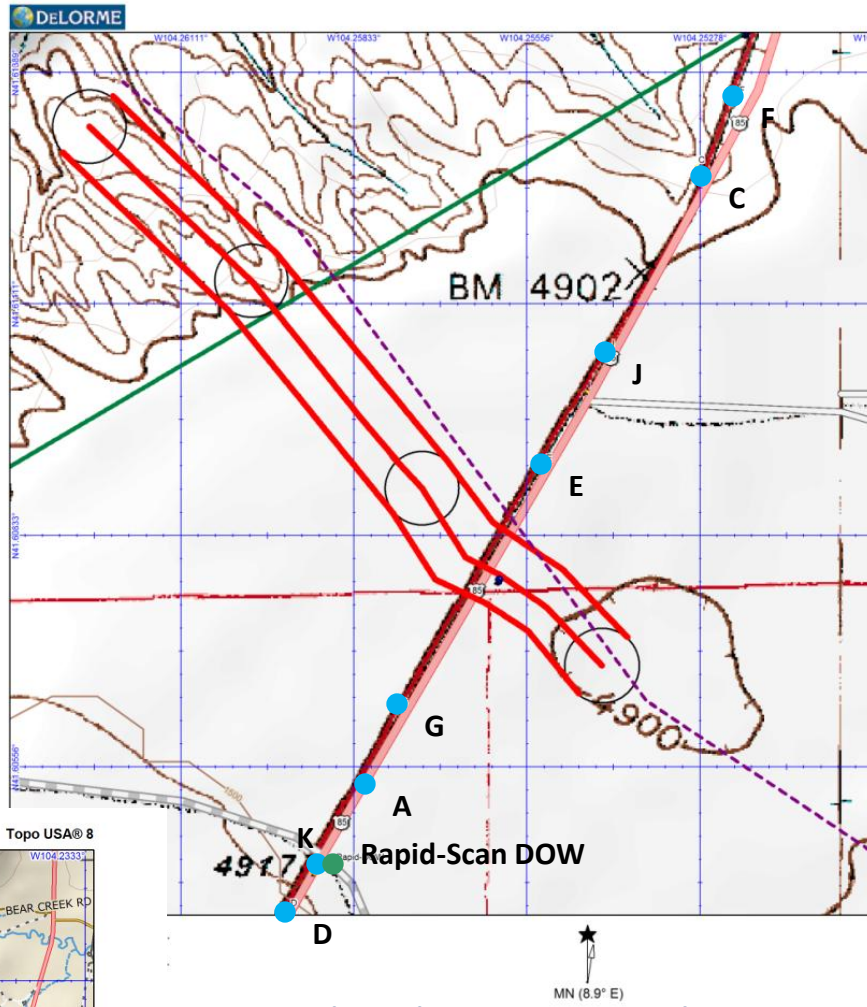
Range ~8 km = 130 m beam width
Could not resolve core flow very well

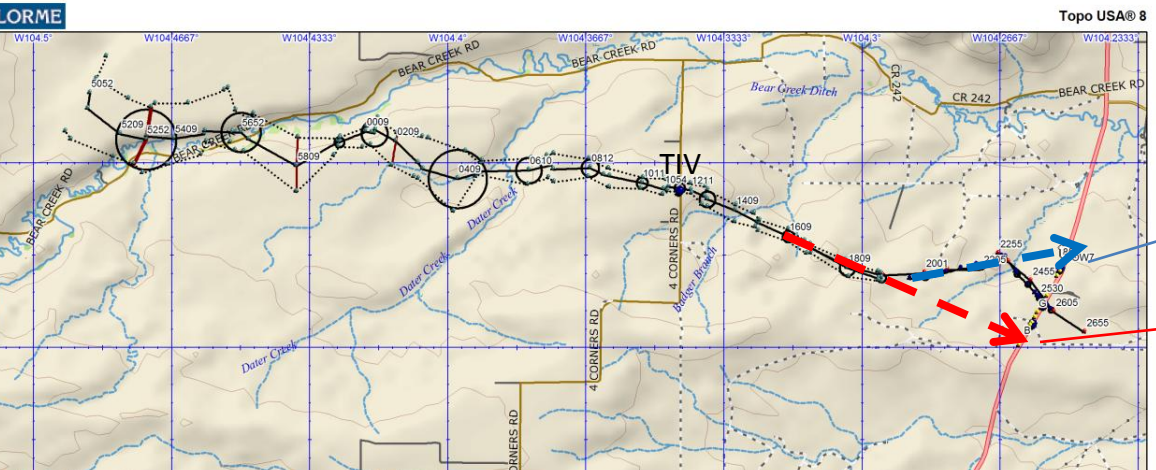
Pods Missed Core Flow of Dying Tornado 05 June

When tornado approached US85, DOW7 and Pod Coordinator had redeployed focusing on DD

Tornado, which was dying with < 50 m diameter core flow, went between Pod arrays.

No Low Level (<50 m AGL) DOW measurements combined with 1 m AGL Pod measurements.

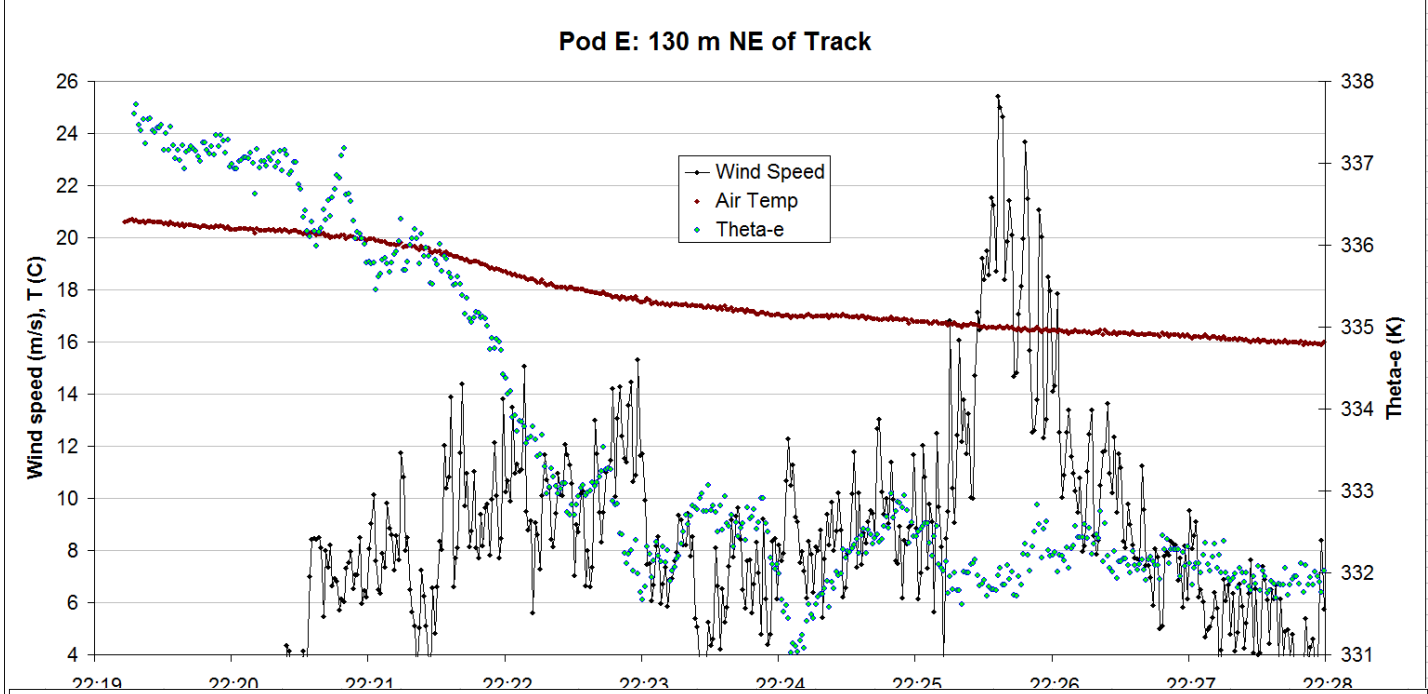


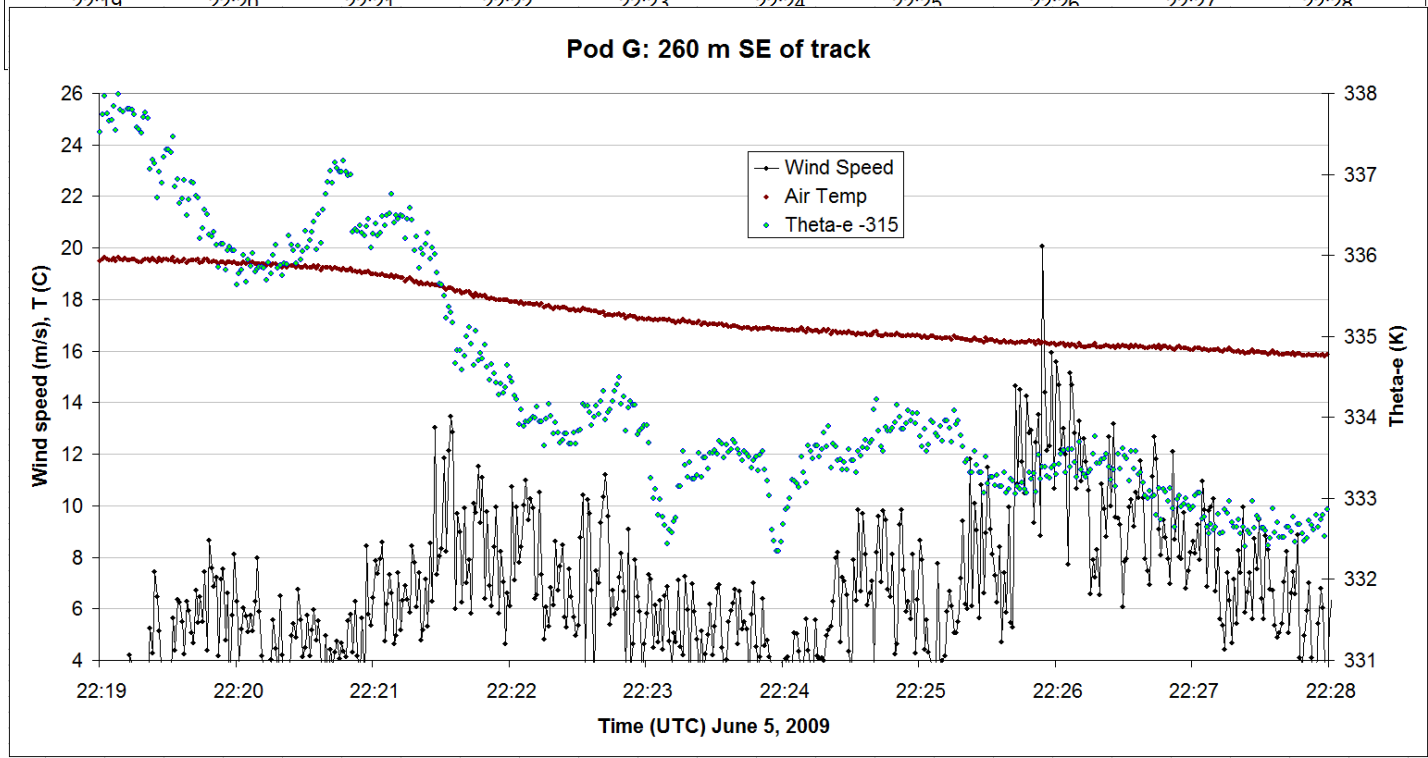


Second Pod Array, tornado moving ENE

Initial Pod Array, tornado moving ESE

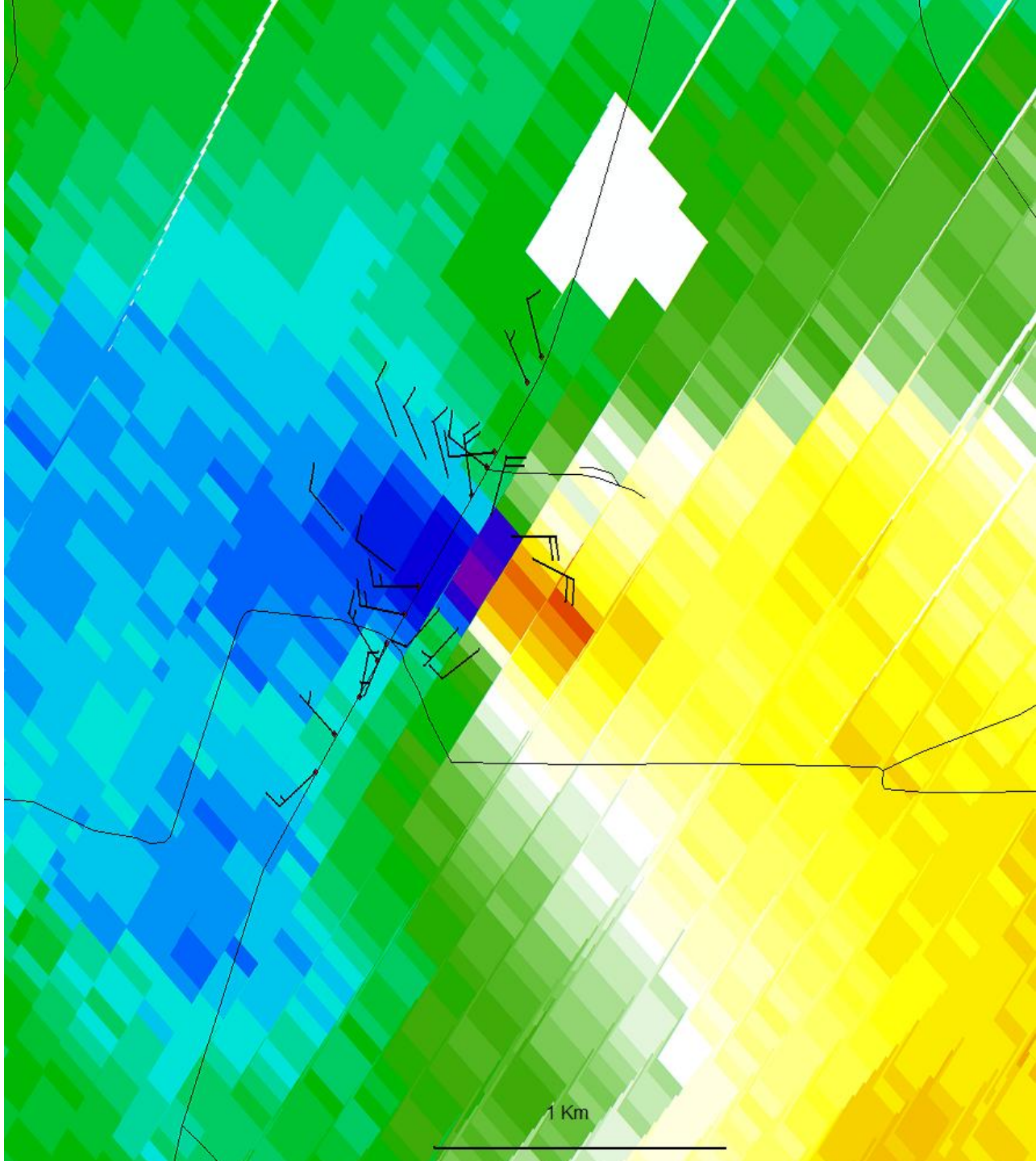
Pod Time Series North and South of Tornado





Wind and Thermo measurements outside core flow may be useful for maintenance, (non-maintenance) studies.

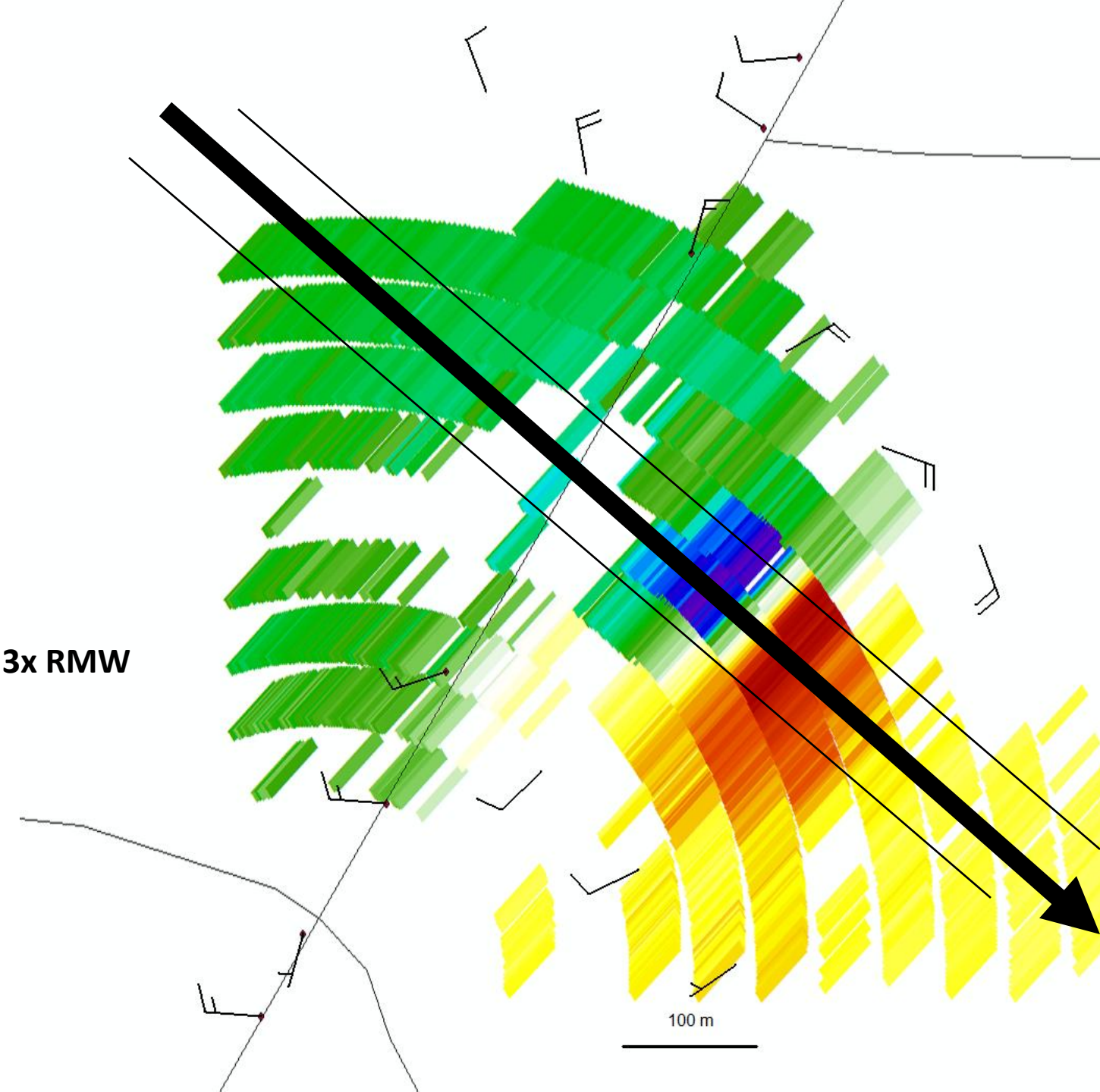
DOW6 and Pods



DOW6 and Pods

Very small RMW

Pod transects @ 2x to 3x RMW

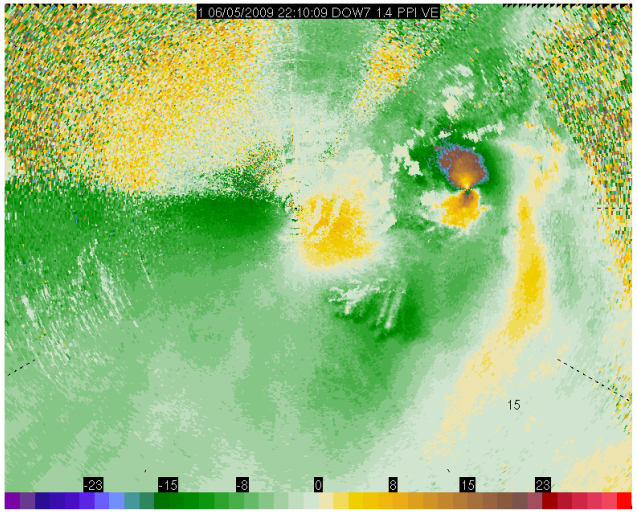


DOW Products

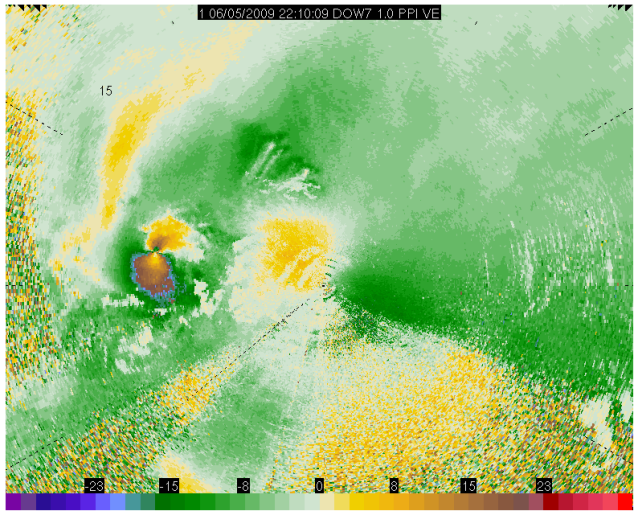
At NCAR and at
cswrdata.org

Topic for Tomorrow:

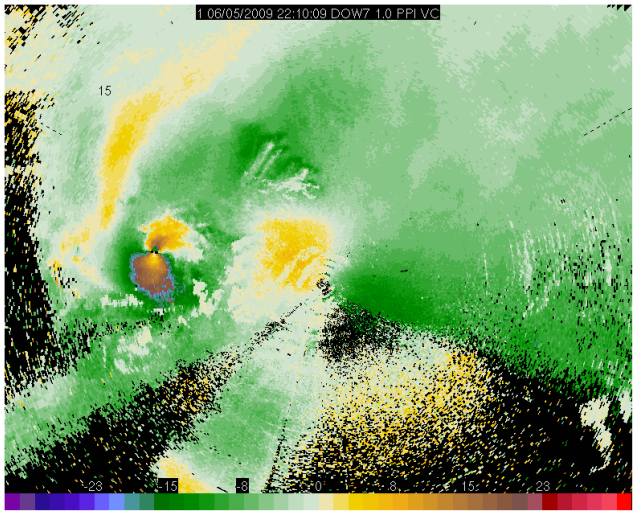
Common dealaising, Common oban, Common Dual-Doppler ??



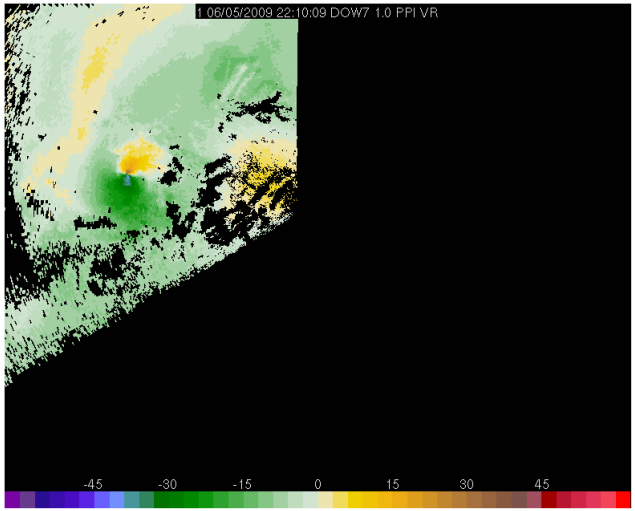
1. Unedited Velocity



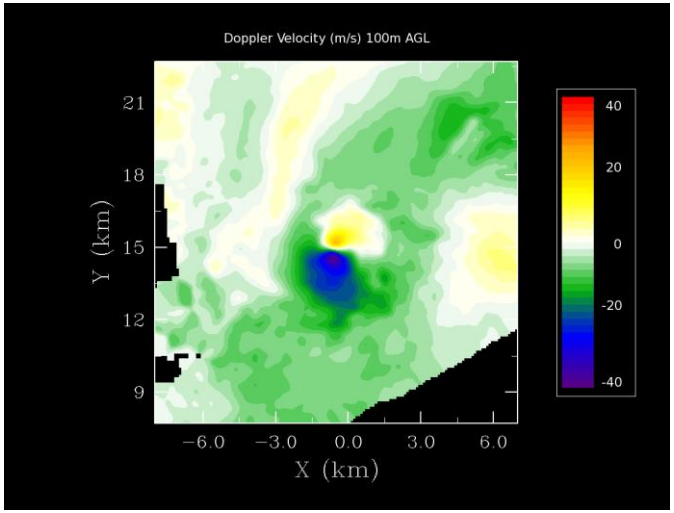
2. Navigated



3. NCP filtered



4. Ground-Clutter Removed, De-aliased



5. Objective Analysis 2-pass Barnes (Dowell/PSU)

Research objectives

- Characterize the kinematic and thermodynamic properties of the flow feeding the tornado throughout during its lifetime
  - Relate these properties to tornadogenesis, maintenance, intensity, structure, and demise

- Foci:
  - The relative importance of the thermodynamic and kinematic properties (spatially and temporally) of the flow feeding the tornado, mechanisms for generating vertical vorticity
  - The importance of corner flow collapse on the mesocyclone/supra-tornado scale in the tornadogenesis (and intensification) process, in particular the origins and generation regions of high momentum fluid
  - The origins of flow feeding the tornado

- Data required:
  - Dual-Doppler DOW data, Rapid-Scan DOW data
  - Mesonet data
  - Pod data

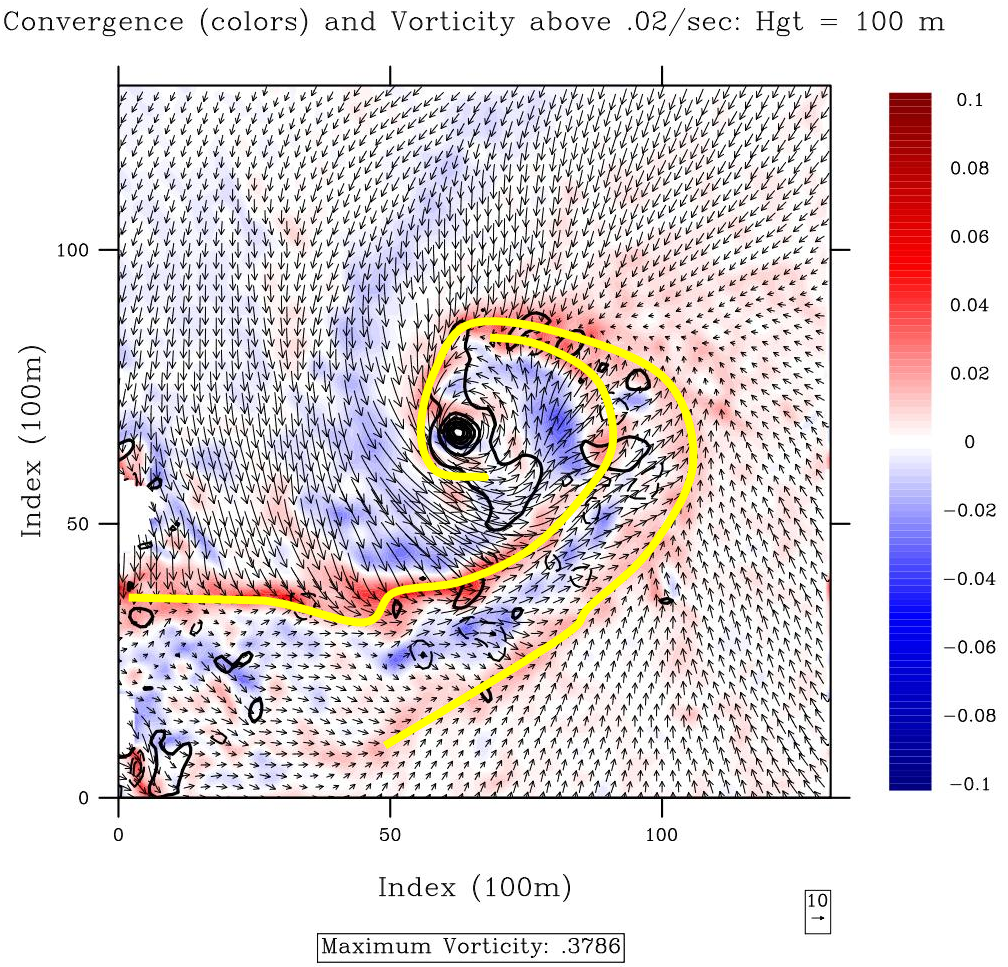
- Methodology:
  - Dual-Doppler/Trajectory analysis
  - Large eddy simulations

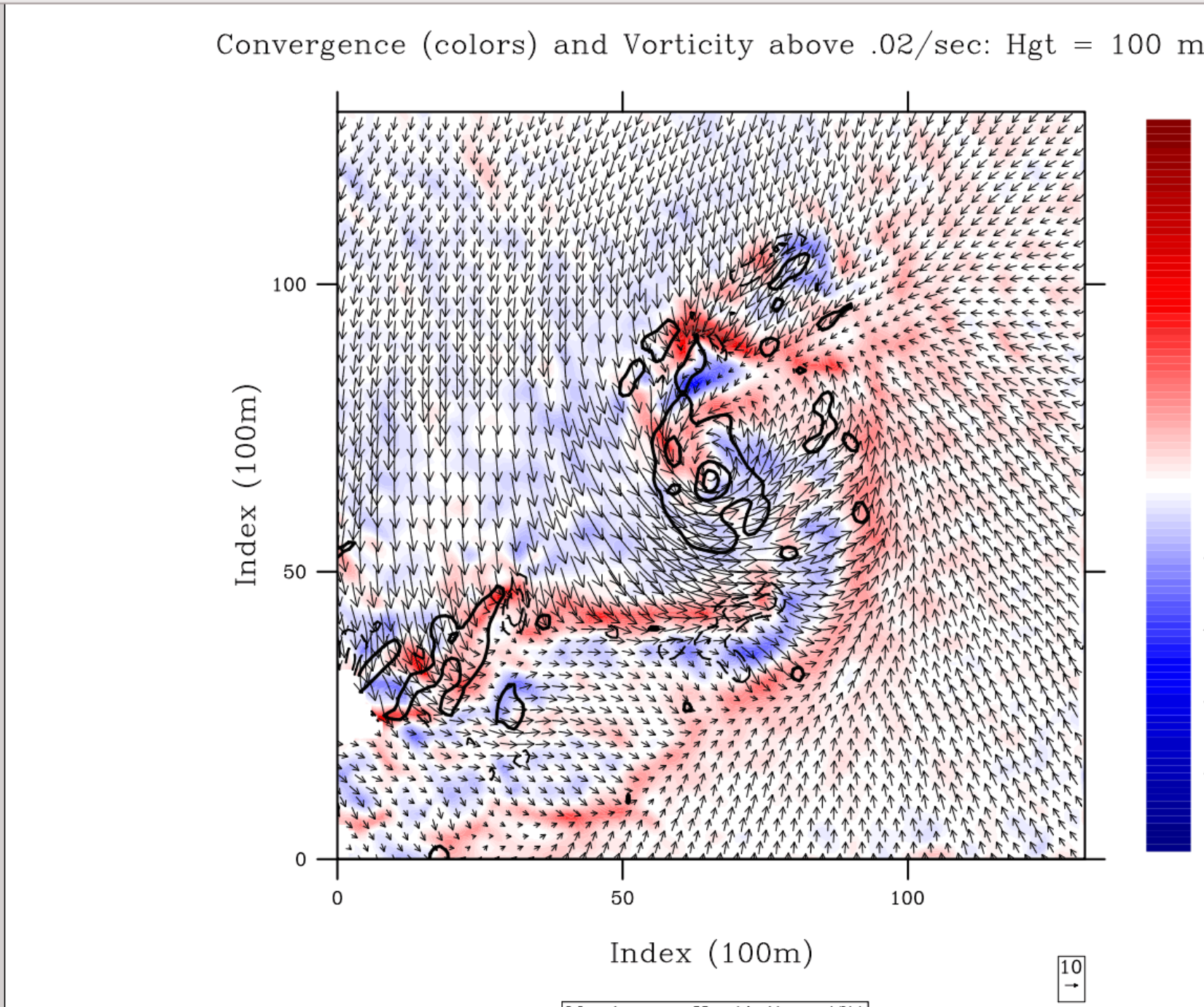
- Wen-Chau Lee: GBVTD analysis of tornado and surrounding flow

Dual-Doppler

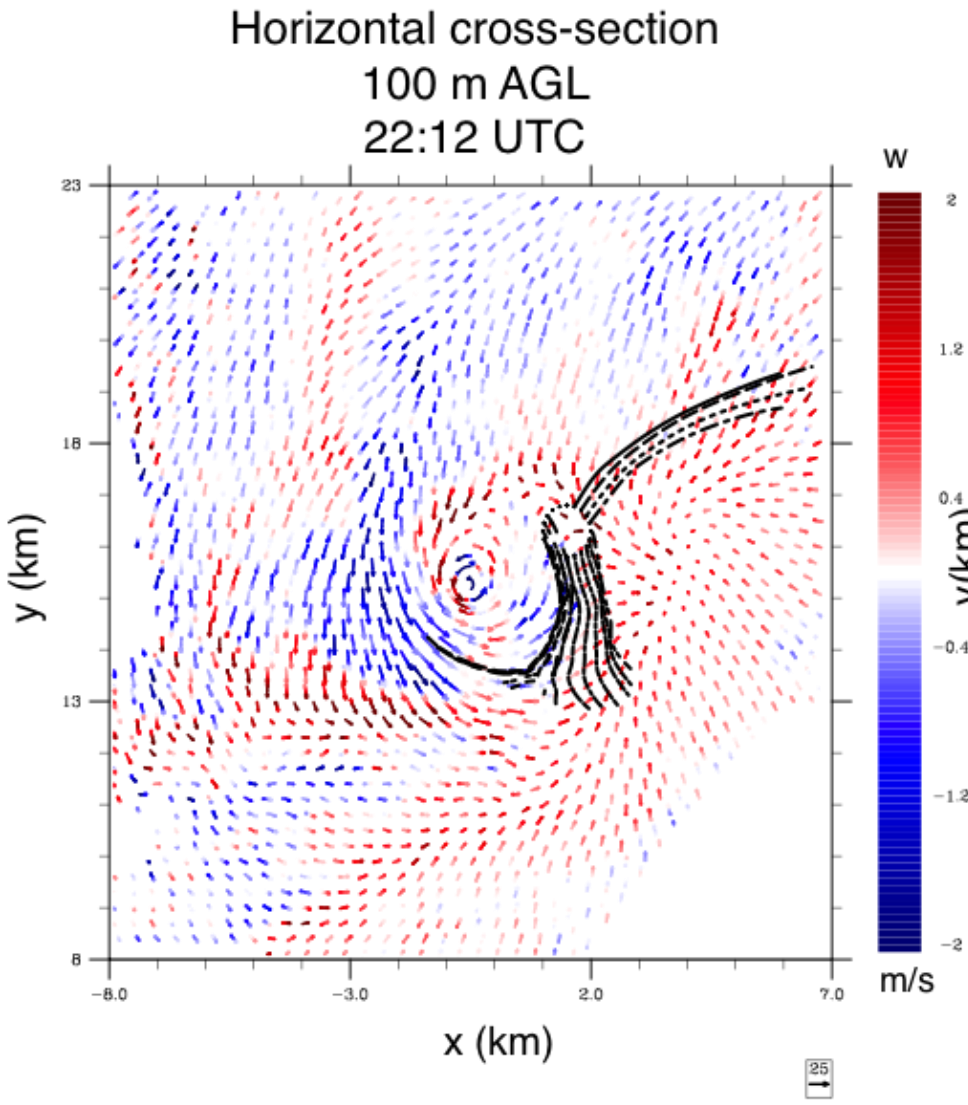
- Double Gust Front
- RFD with ~0 vorticity
- Trackable Vorticity Beads on Gust Front
- Peak RFD divergence several minutes before tornado intensification
- Two-Phase Tornado history, maybe 2 tornadoes?
- Cycloidal Motion

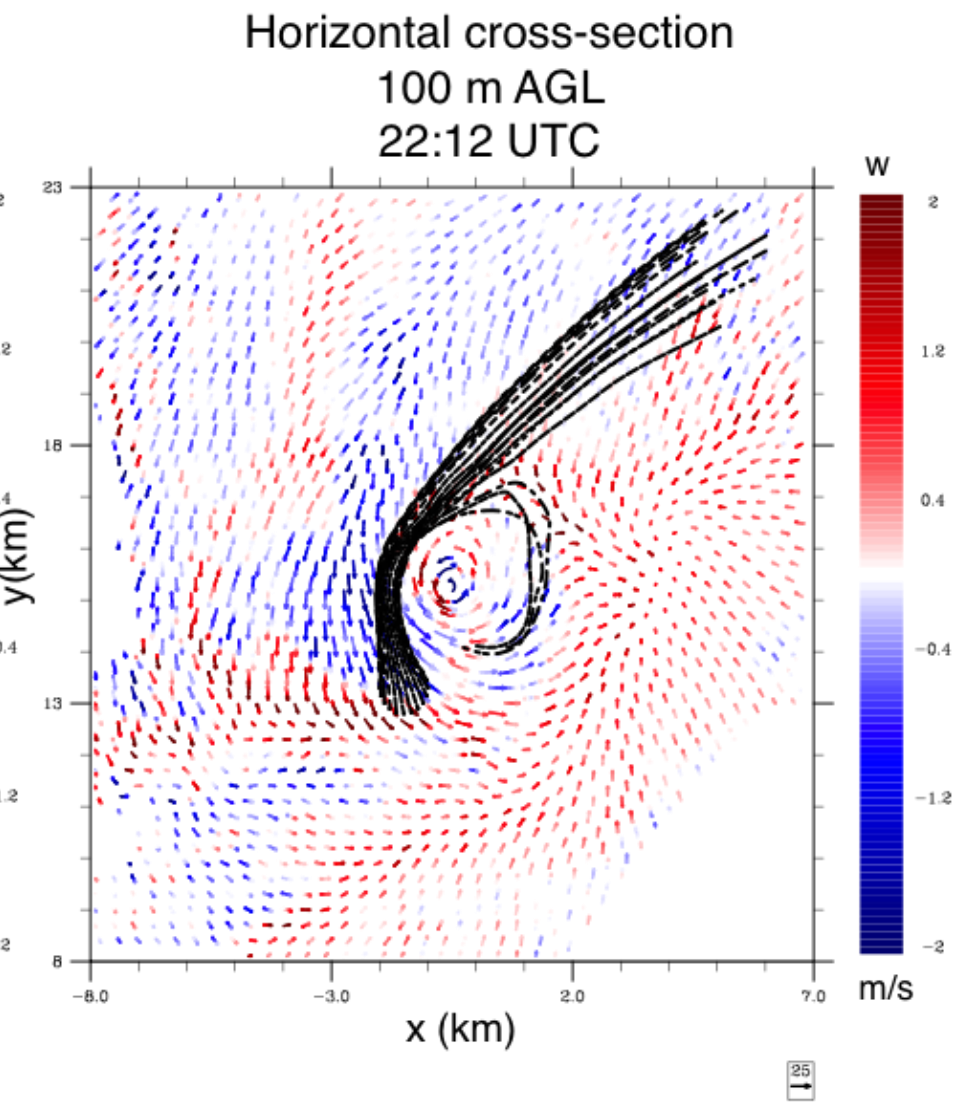
Convergence shaded
Vorticity contoured (0.02 s-1)

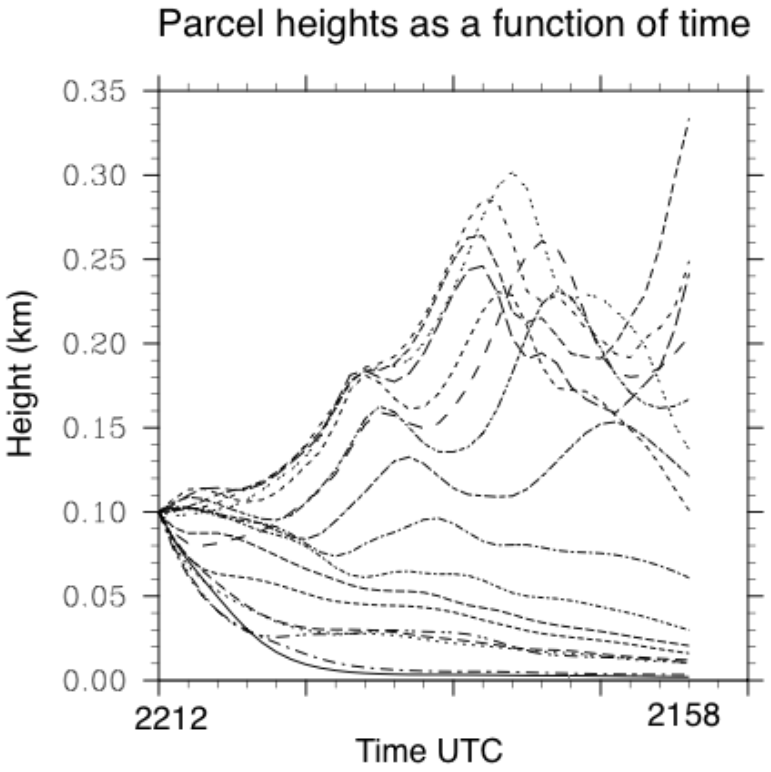


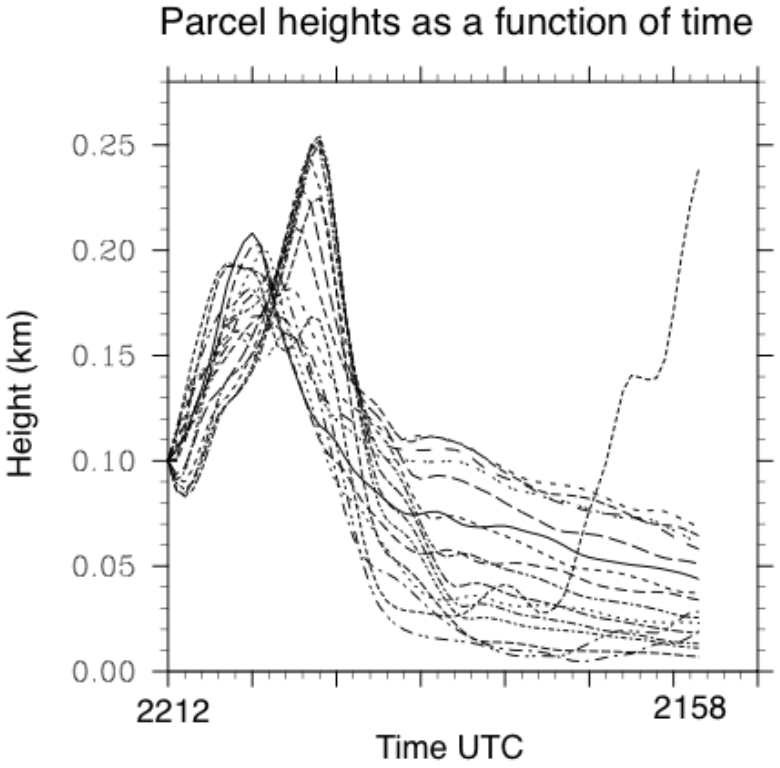

Convergence (colors) and Vorticity above .02/sec: Hgt = 100 m
Index (100m)
0
50
100
Index (100m)
0
50
100
10
Maximum Vorticity: .171

Backward trajectories from 22:12 to 21:58 UTC

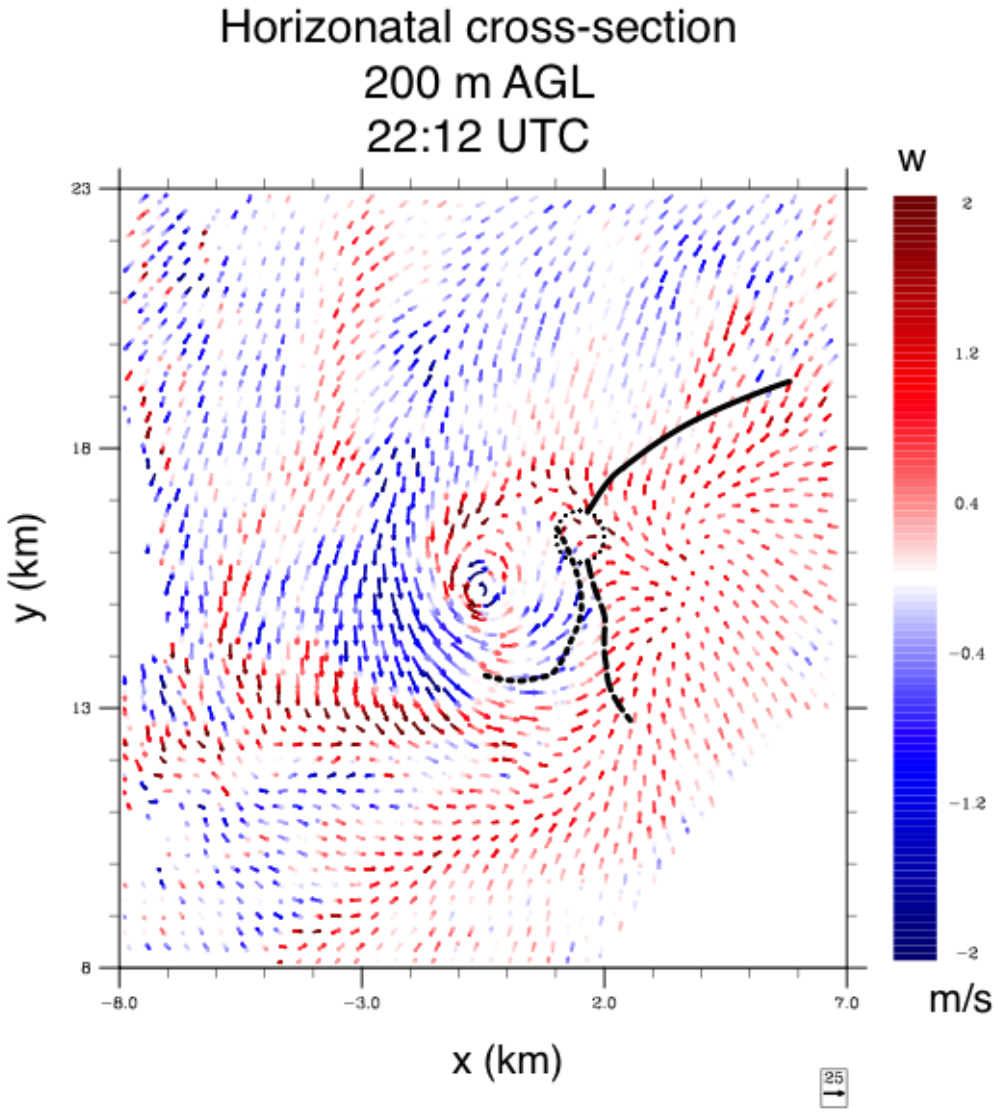


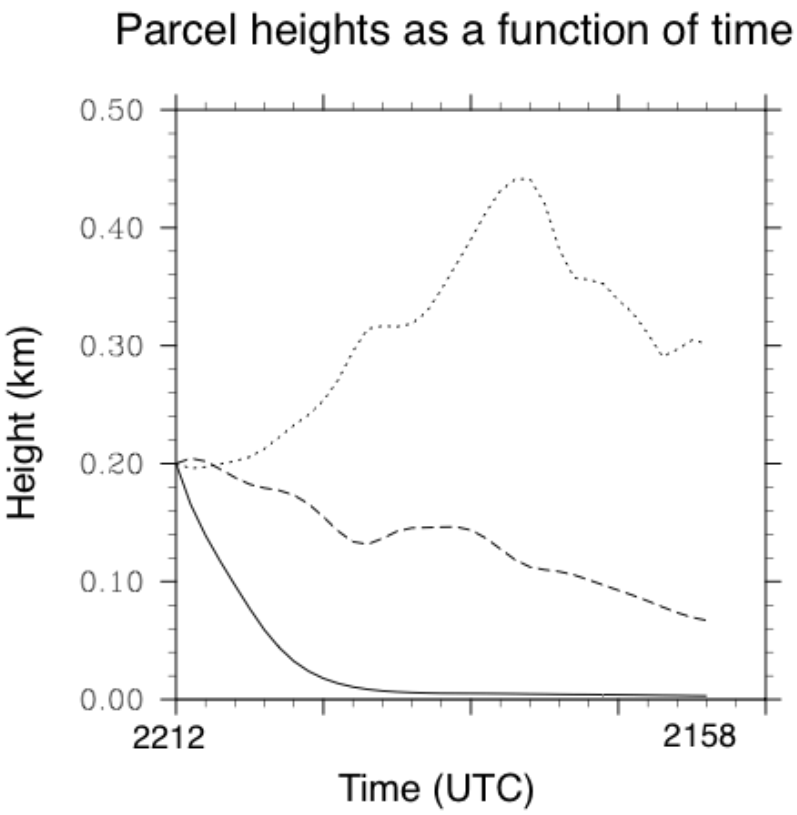



Parcel heights as a function of time
Height (km)
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
2212
2158
Time UTC

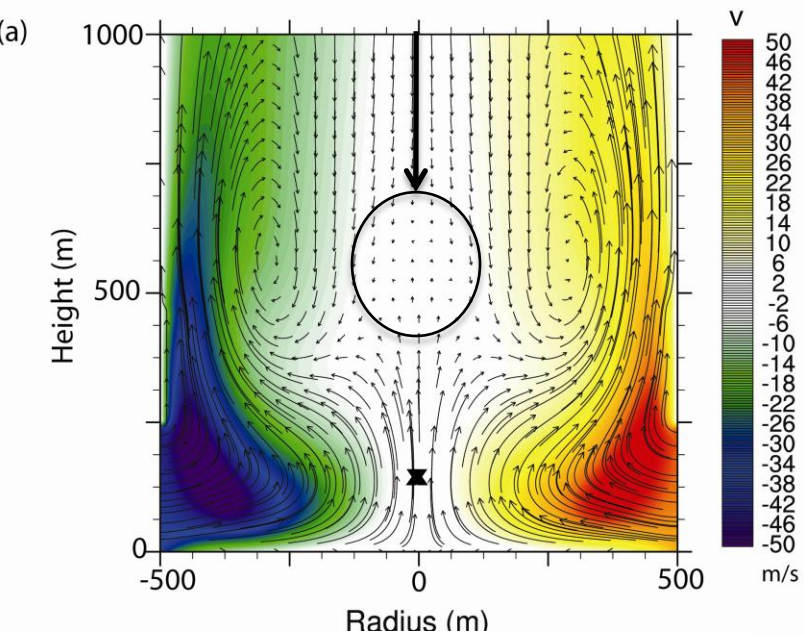

Parcel heights as a function of time
Height (km)
0.25
0.20
0.15
0.10
0.05
0.00
2212
2158
Time UTC

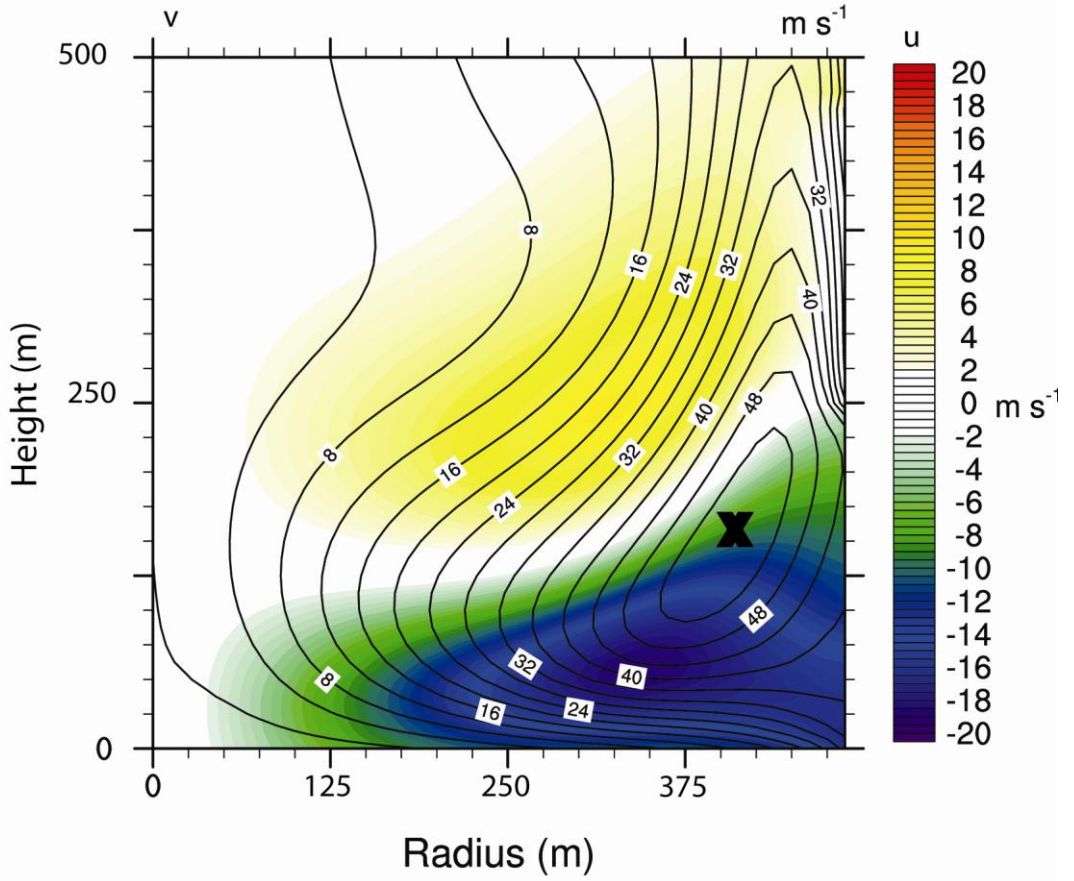
Parcel properties as a function of source region



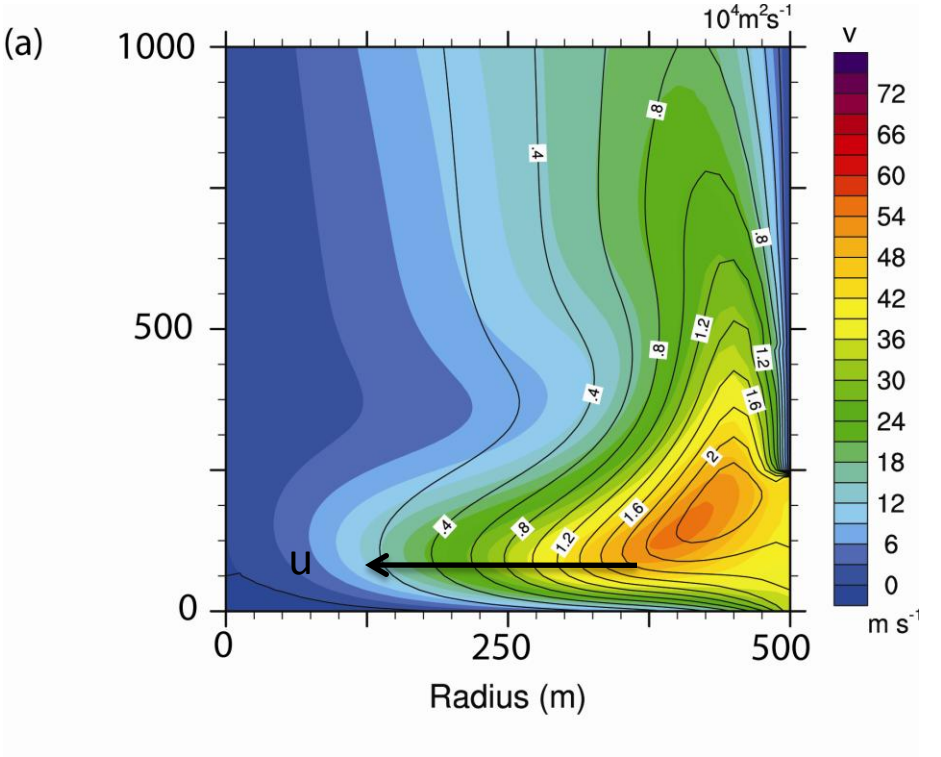


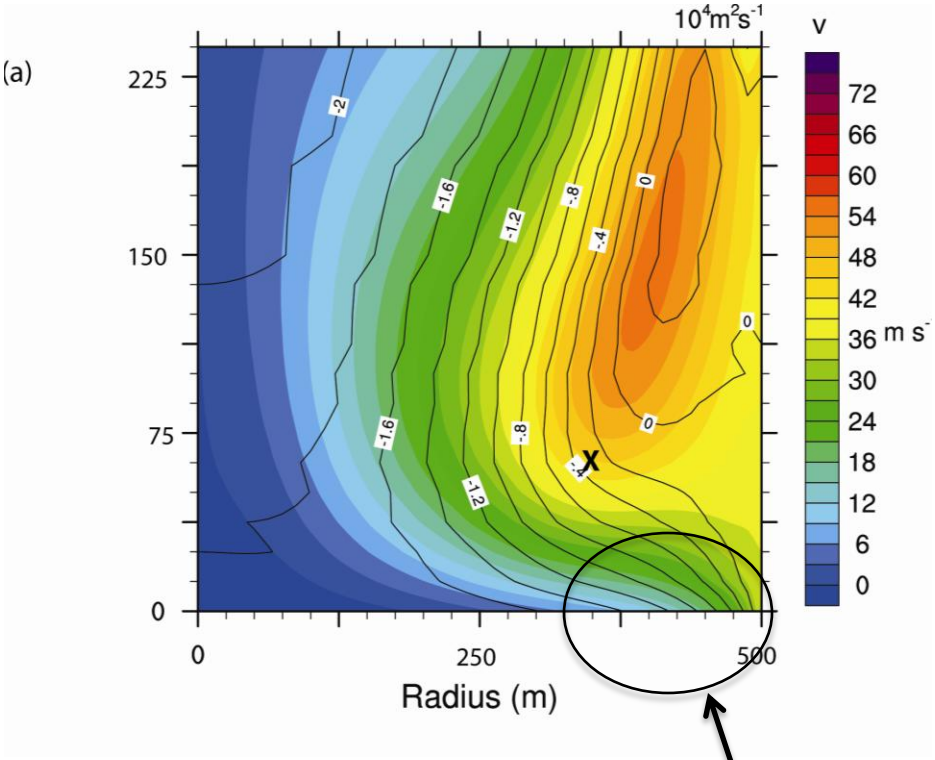
Spencer, SD LES





Spencer, SD LES





Largest rate of angular momentum depletion with radius