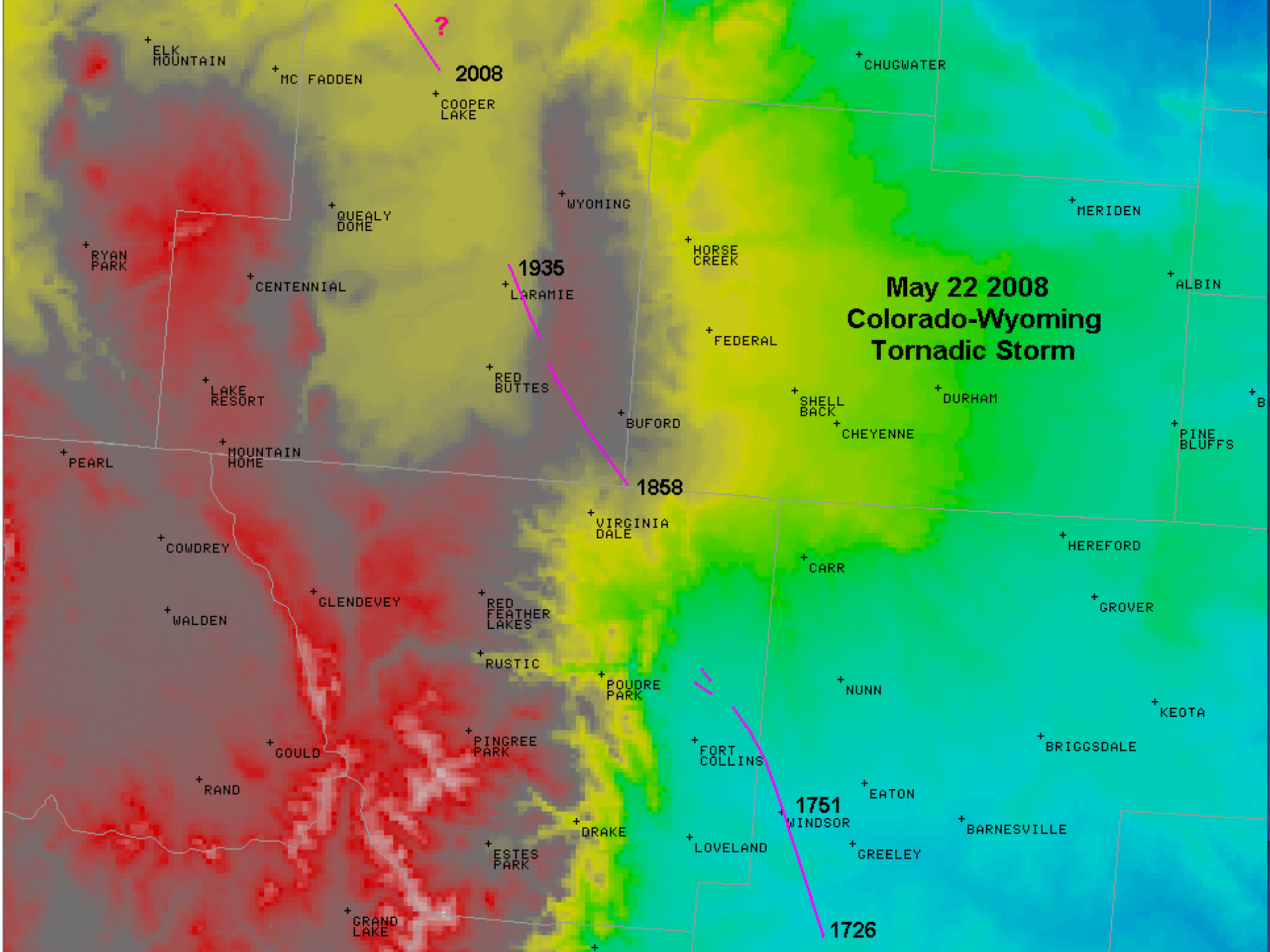
The May 22 2008 Colorado-Wyoming Long-Lived Tornadic Supercell

Jonathan Finch (NWS WFO Dodge City)

Dan Bikos (CIRA/Colorado State University)

Very Rare Events!!

- Storm developed near the Denver airport and produced severe weather over a 3.5 hour period and over 140 miles (well beyond Laramie,WY)
- Large, Long -Track Tornado on Colorado Front Range
- Damaging tornado in Laramie Mts. (elev. 7500-8700 ft) in dense fog and temperatures from 43 to 47F
- Laramie hit by F1 tornado
- Baseball sized hail at 8400 ft on the Laramie Range
- Thundersnow in Laramie Range 5 hours after the tornado moved across the same area (3 to 6” accumulations)


May 22 2008
Colorado-Wyoming
Tornadic Storm
?
2008
1935
1858
1751
1726
ELK MOUNTAIN
MC FADDEN
COOPER LAKE
CHUGWATER
QUEALY DOME
WYOMING
MERIDEN
RYAN PARK
CENTENNIAL
LARAMIE
HORSE CREEK
ALBIN
FEDERAL
LAKE RESORT
RED BUTTES
SHELL BACK
DURHAM
BUFORD
CHEYENNE
PINE BLUFFS
PEARL
MOUNTAIN HOME
VIRGINIA DALE
COWDREY
HEREFORD
CARR
GLENDEVEY
WALDEN
RED FEATHER LAKES
GROVER
RUSTIC
POUDRE PARK
NUNN
KEOTA
PINGREE PARK
GOULD
FORT COLLINS
BRIGGSDALE
RAND
EATON
WINDSOR
DRAKE
BARNESVILLE
LOVELAND
ESTES PARK
GREELEY
GRAND LAKE

Windsor, CO Wedge Tornado

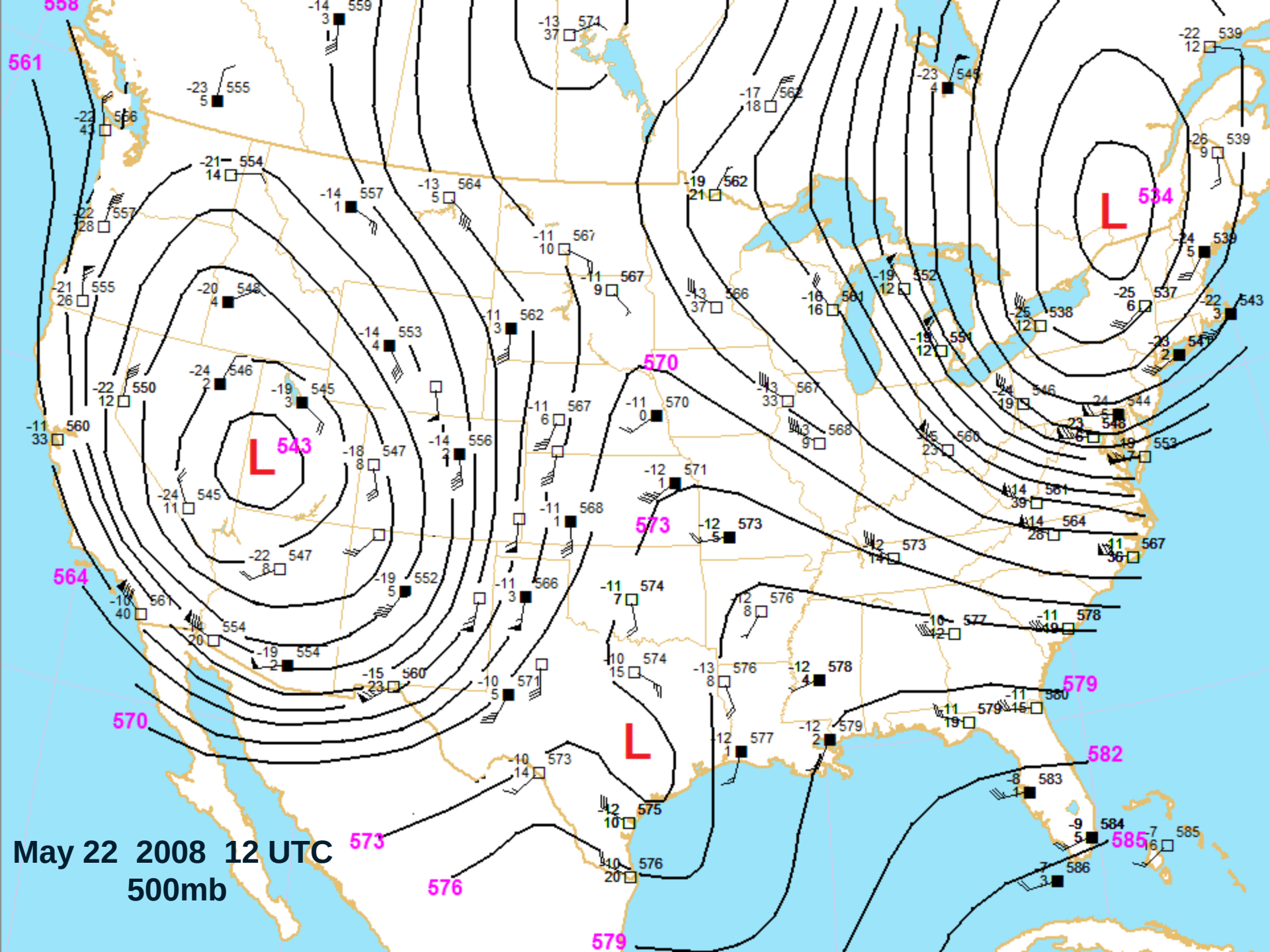
Trees Down Northwest of Vedauwoo, WY

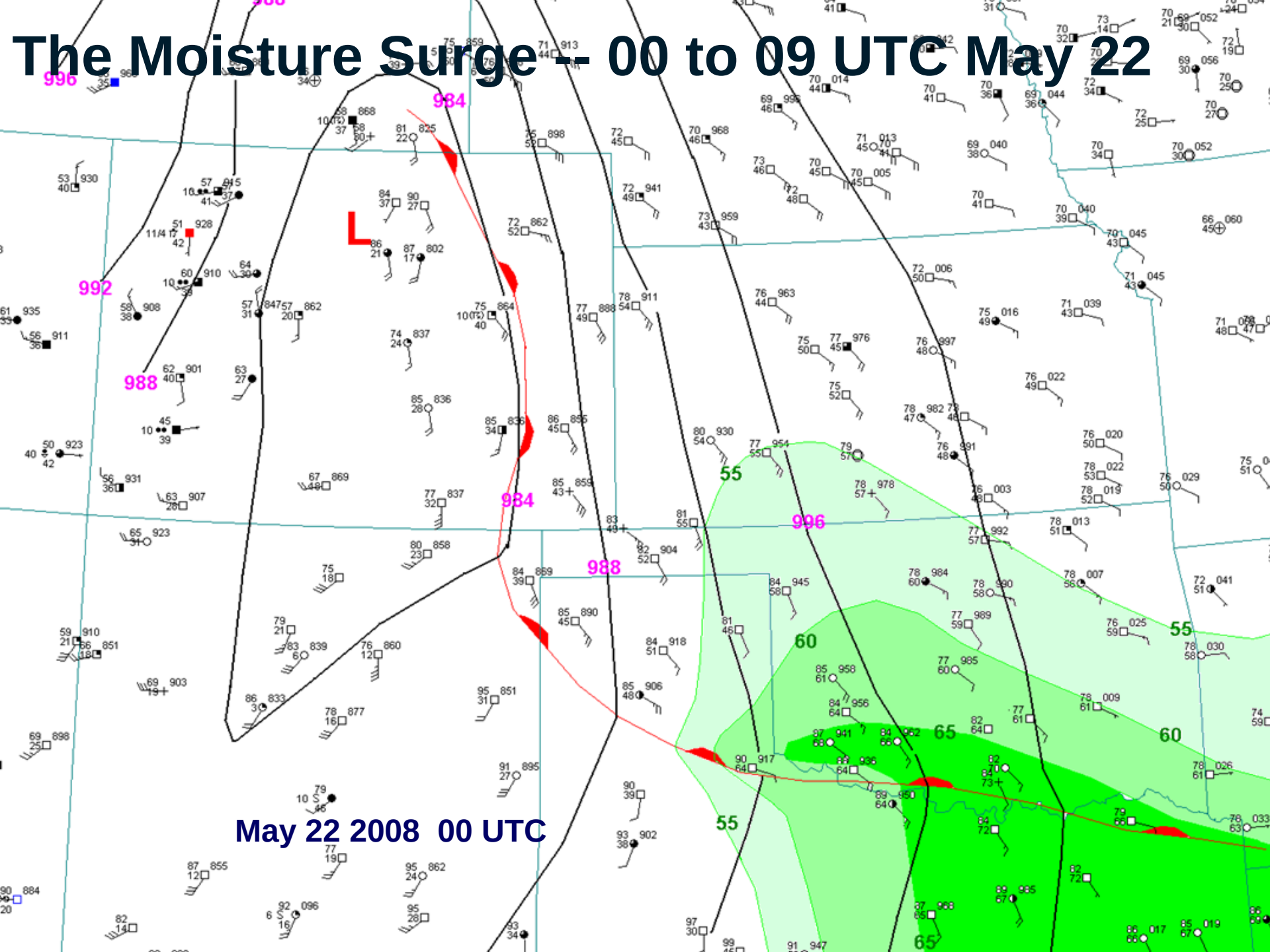
The Meridional Upper Pattern with Laramie Range Tornadoes

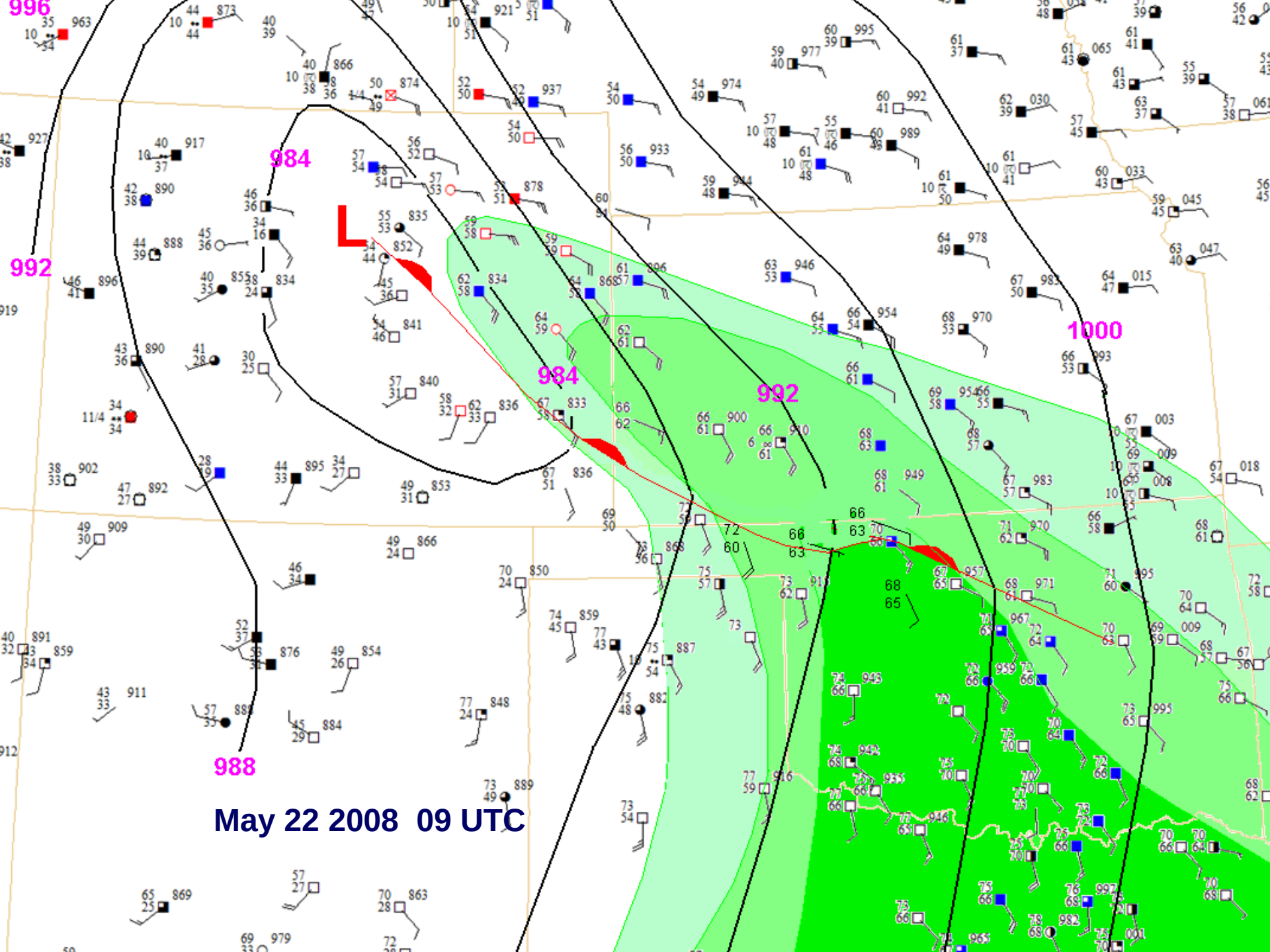
April 23 1960

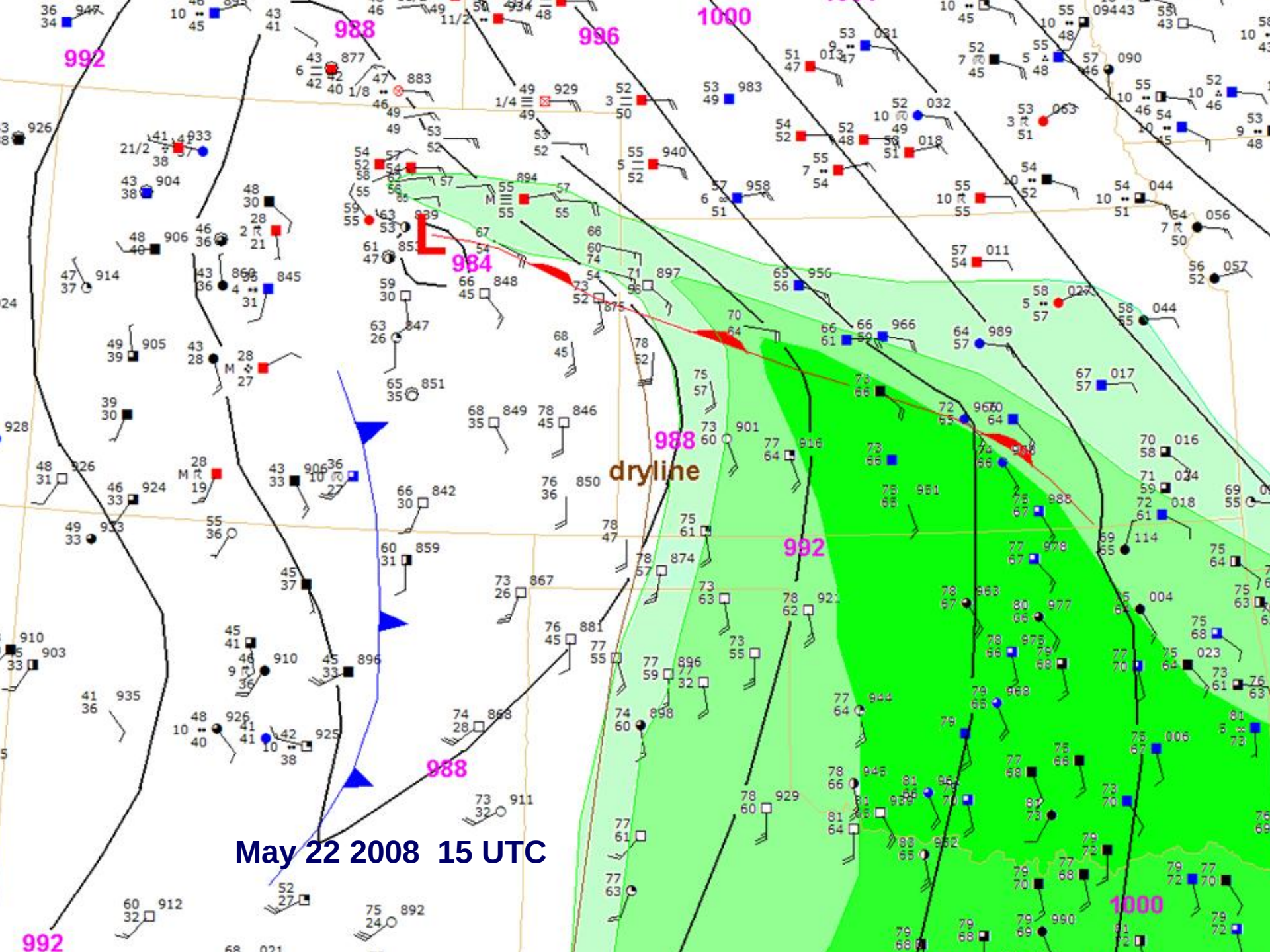
June 15 1965

May 22 2008

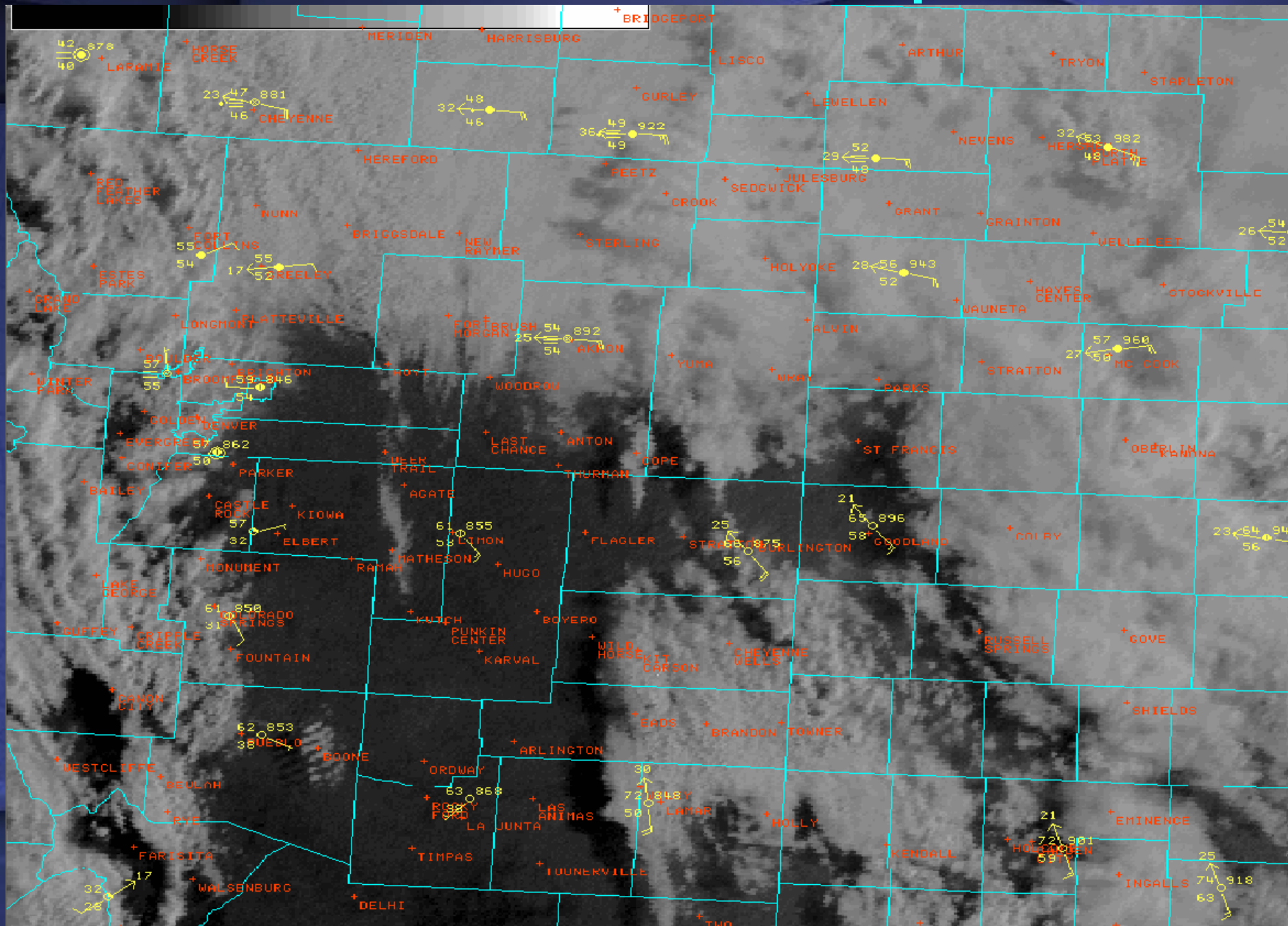

May 22 2008 12 UTC
500mb


The Moisture Surge -- 00 to 09 UTC May 22
May 22 2008 00 UTC

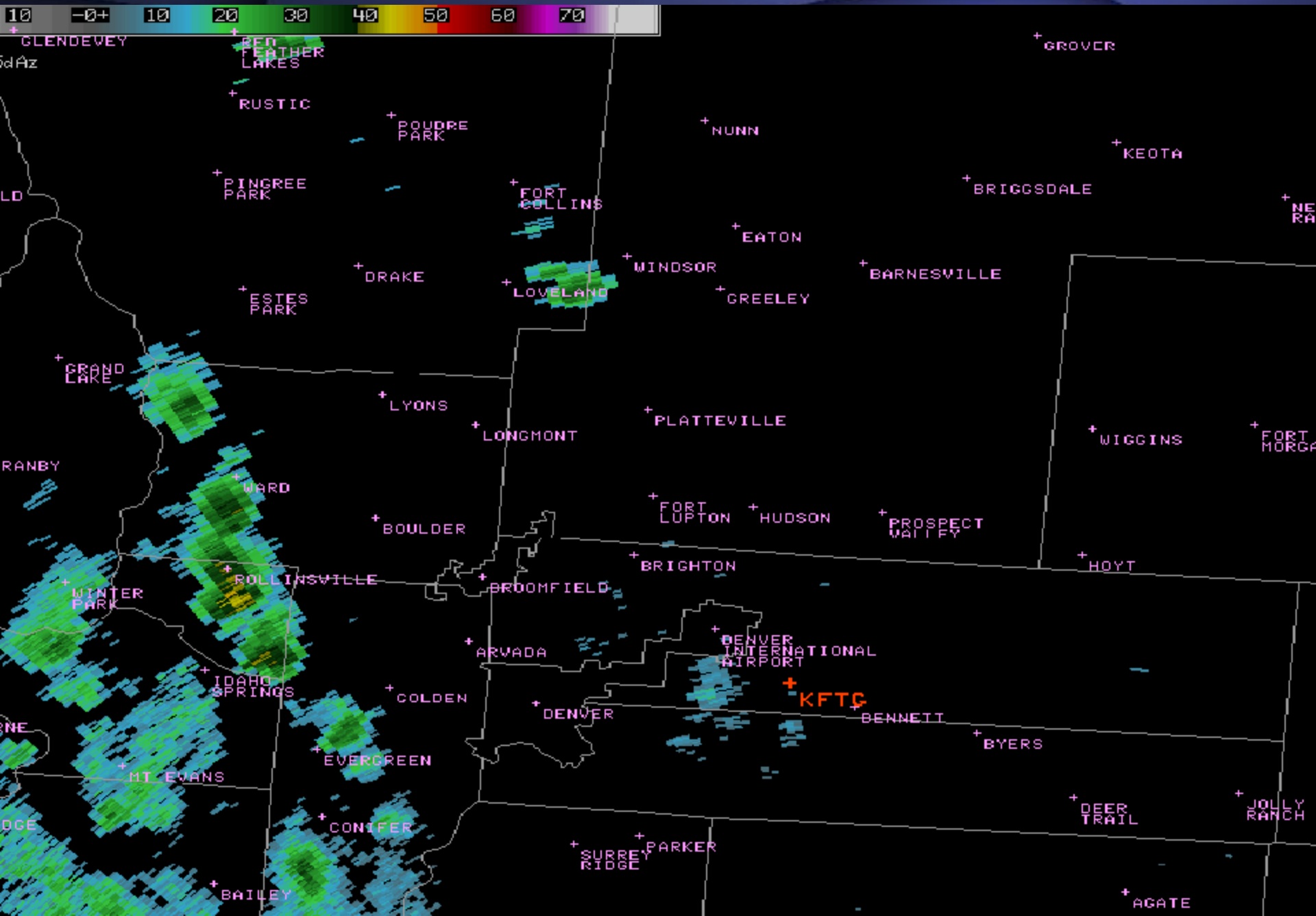

996
992
984
988
984
992
1000
May 22 2008 09 UTC


dryline
May 22 2008 15 UTC

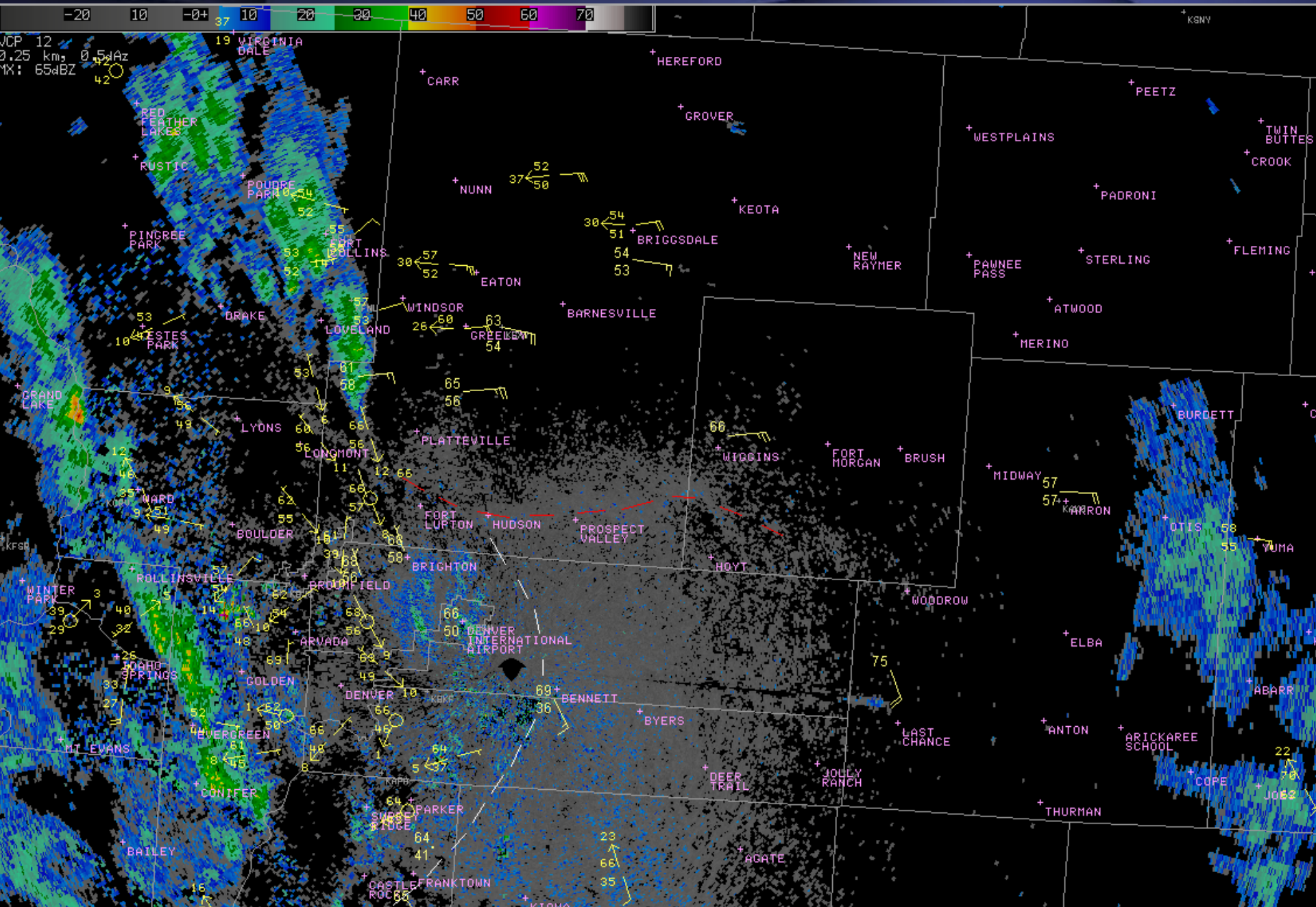
Visible Satellite Loop



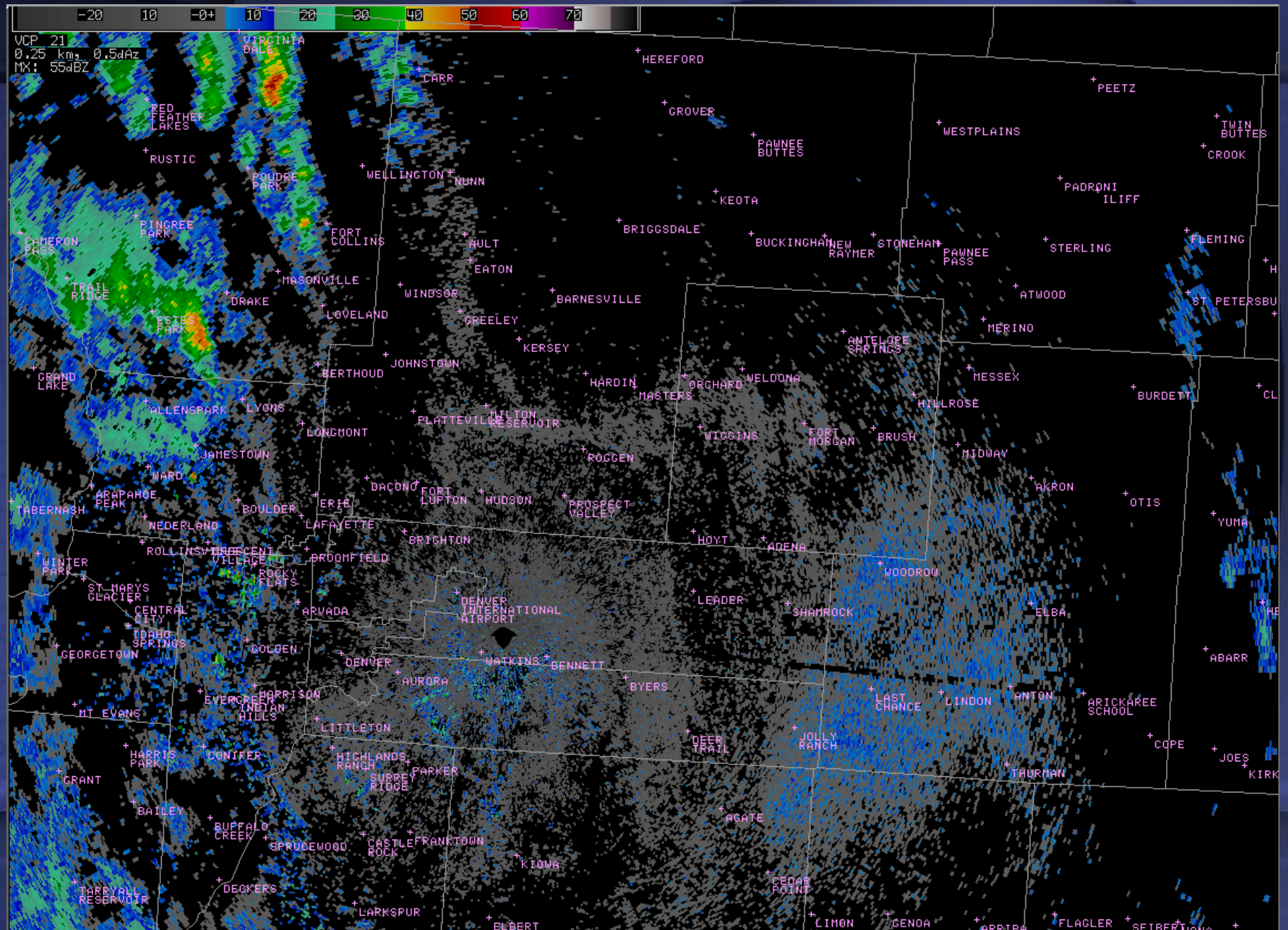
Pueblo Radar Loop

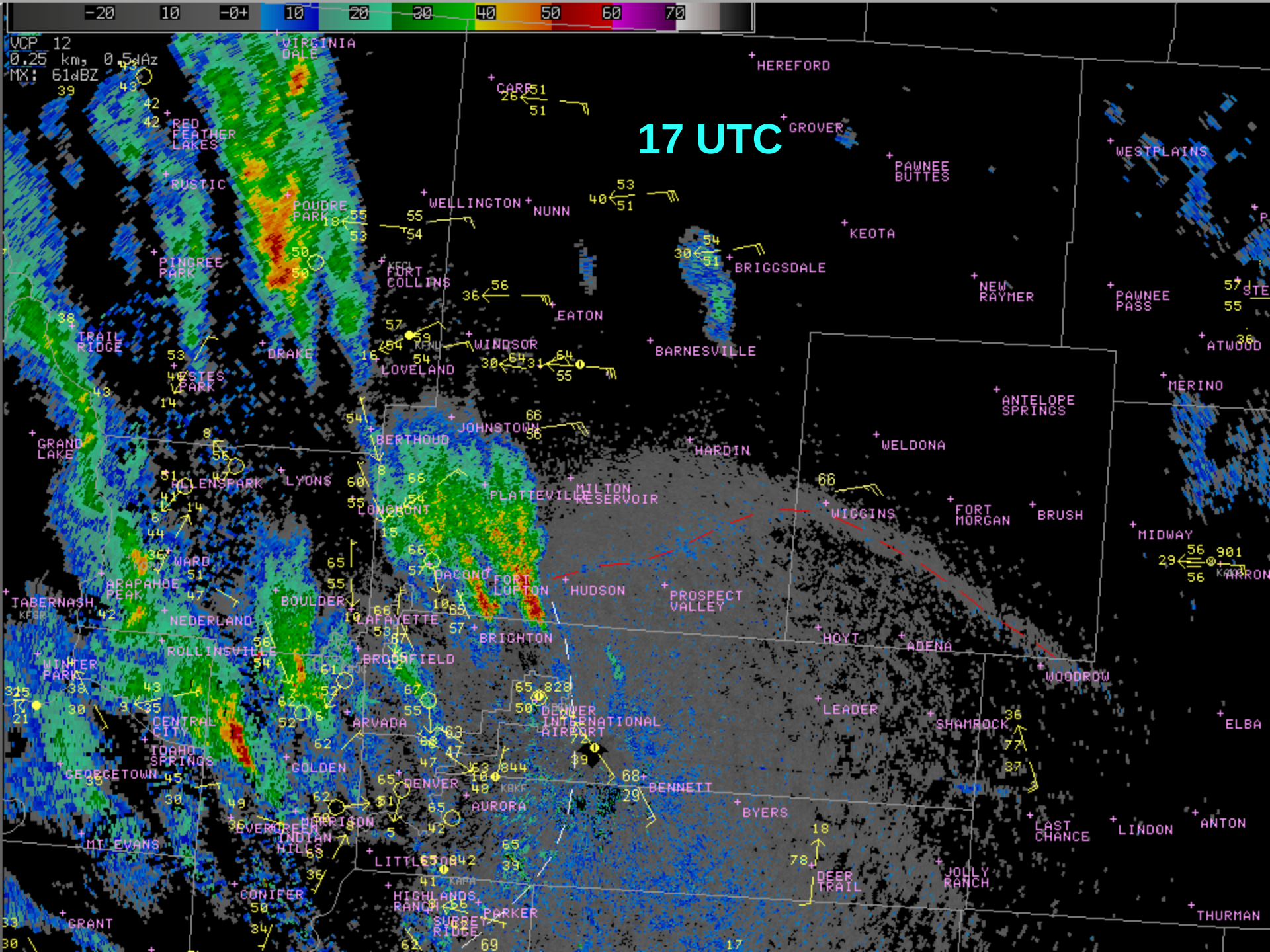


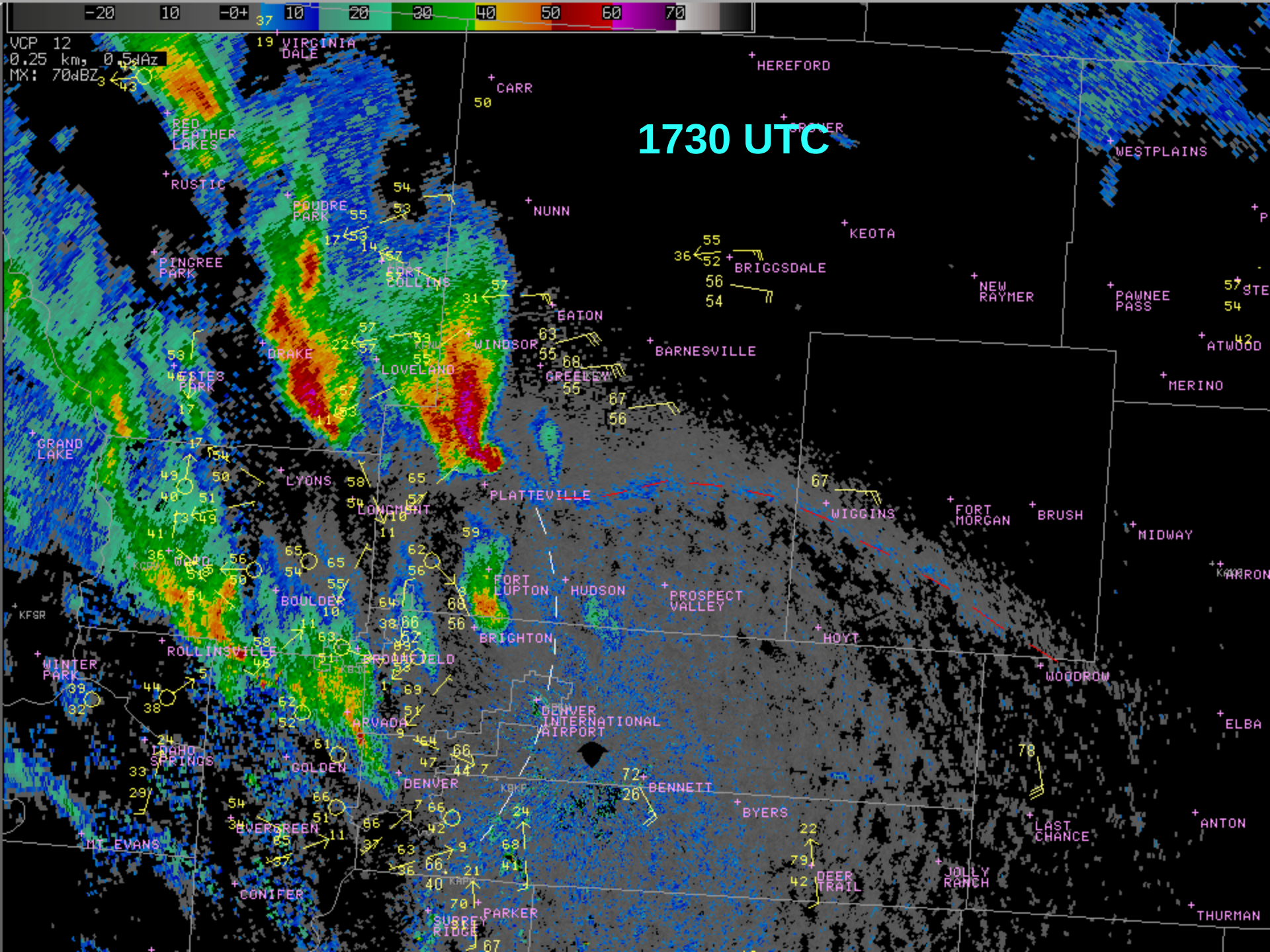
Initiation Time 1630 UTC



KFTG .5° Reflectivity Loop




-20 10 -0+ 10 20 30 40 50 60 70
VCP 12
0.25 km, 0.5dAz
MX: 61dBZ
17 UTC
VIRGINIA DALE
HEREFORD
CARR
GROVER
RED FEATHER LAKES
RUSTIC
POUDRE PARK
WELLINGTON
NUNN
PAWNEE BUTTES
WESTPLAINS
KEOTA
PINGREE PARK
FORT COLLINS
BRIGGSDALE
NEW RAYMER
PAWNEE PASS
EATON
TRAIL RIDGE
DRAKE
WINDSOR
LOVELAND
BARNESVILLE
ATWOOD
ESTES PARK
MERINO
ANTELOPE SPRINGS
GRAND LAKE
JOHNSTOWN
BERTHOUD
HARDIN
WELDONA
ALLENSPARK
LYONS
LONGMONT
PLATTEVILLE
MILTON RESERVOIR
WIGGINS
FORT MORGAN
BRUSH
MIDWAY
WARD
BRAINARD LAKE
DACONO
FORT LUPTON
HUDSON
PROSPECT VALLEY
TABERNASH
BOULDER
NEDERLAND
LAFAYETTE
BRIGHTON
HOYT
ADENA
ROLLINSVILLE
BROOMFIELD
WOODROW
WINTER PARK
CENTRAL CITY
ARVADA
DENVER INTERNATIONAL AIRPORT
LEADER
SHAMROCK
ELBA
IDAHO SPRINGS
GEORGETOWN
GOLDEN
DENVER
BENNETT
AURORA
BYERS
LAST CHANCE
LINDON
ANTON
MT EVANS
EVERGREEN
INDIAN HILLS
HARRISON
LITTLETON
DEER TRAIL
JOLLY RANCH
CONIFER
HIGHLANDS RANCH
PARKER
SURREY RIDGE
GRANT
THURMAN


-20 10 -0+ 10 20 30 40 50 60 70
VCP 12
0.25 km, 0.5dAz
MX: 70dBZ
1730 UTC
VIRGINIA DALE
HEREFORD
CARR
RED FEATHER LAKES
RUSTIC
POUDRE PARK
NUNN
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ATWOOD
MERINO
FORT COLLINS
EATON
WINDSOR
BARNESVILLE
GREELEY
LOVELAND
DRAKE
ESTES PARK
GRAND LAKE
LYONS
LONGMONT
PLATTEVILLE
WIGGINS
FORT MORGAN
BRUSH
MIDWAY
BOULDER
FORT LUPTON
HUDSON
PROSPECT VALLEY
BRIGHTON
HOYT
WOODROW
ROLLINSVILLE
WINTER PARK
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DENVER INTERNATIONAL AIRPORT
ELBA
IDAHO SPRINGS
GOLDEN
DENVER
BENNETT
BYERS
LAST CHANCE
ANTON
EVERGREEN
MT EVANS
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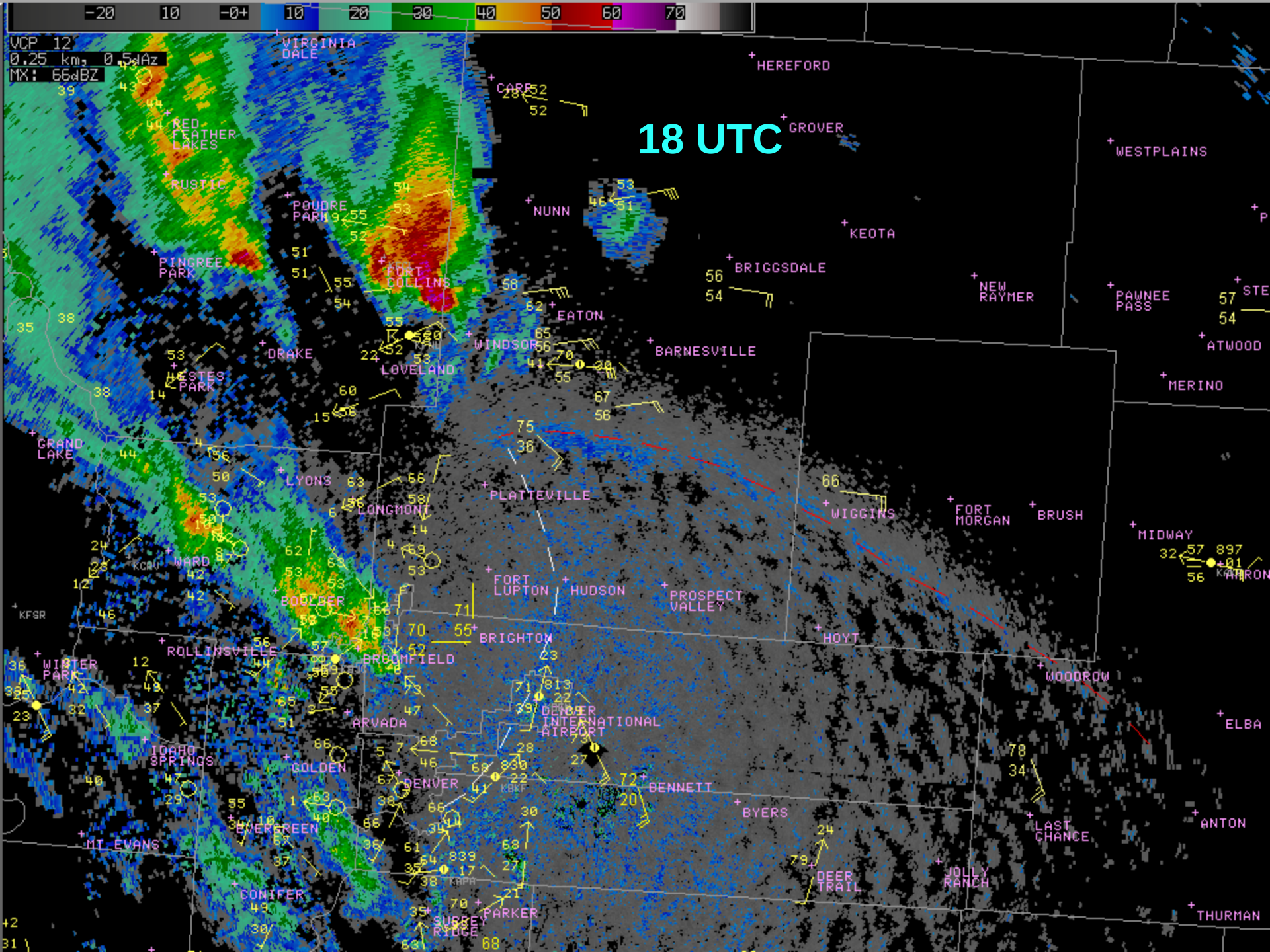
DEER TRAIL
JOLLY RANCH
PARKER
SURREY RIDGE
THURMAN


-20 10 -0+ 10 20 30 40 50 60 70
VCP 12
0.25 km, 0.5dAz
MX: 66dBZ
18 UTC
VIRGINIA DALE
HEREFORD
CARR
GROVER
WESTPLAINS
RED FEATHER LAKES
RUSTIC
POUDRE PARK
NUNN
KEOTA
PINGREE PARK
FORT COLLINS
BRIGGSDALE
NEW RAYMER
PAWNEE PASS
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WINDSOR
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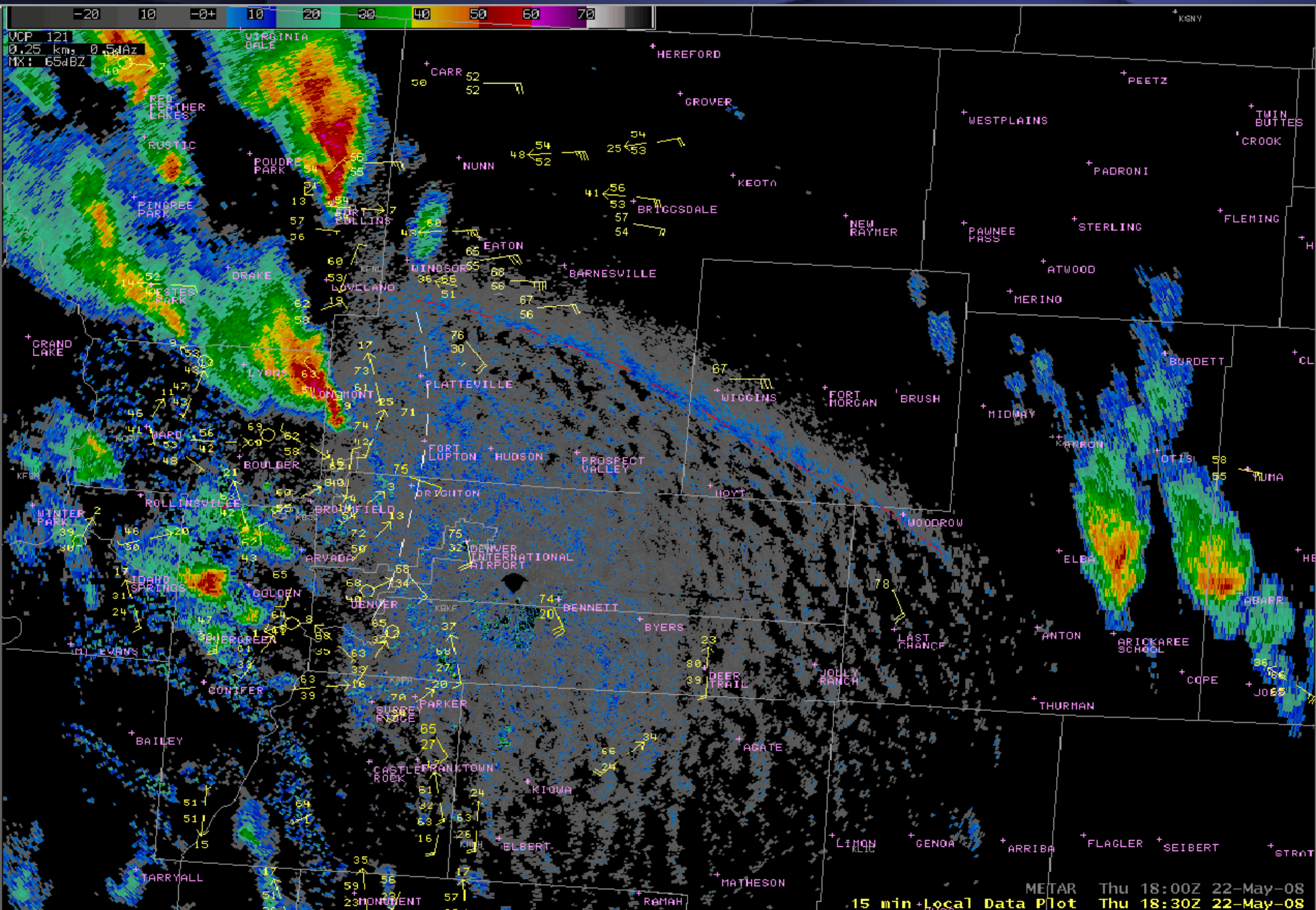
WIGGINS
FORT MORGAN
BRUSH
MIDWAY
WARD
BOULDER
FORT LUPTON
HUDSON
PROSPECT VALLEY
KFSR
BRIGHTON
HOYT
ROLLINSVILLE
BROOMFIELD
WOODROW
WINTER PARK
ARVADA
DENVER INTERNATIONAL AIRPORT
ELBA
IDAHO SPRINGS
GOLDEN
DENVER
BENNETT
BYERS
LAST CHANCE
ANTON
MT EVANS
EVERGREEN
DEER TRAIL
JOLLY RANCH
CONIFER
PARKER
SUBREY RIDGE
THURMAN

Surface Boundary Loop



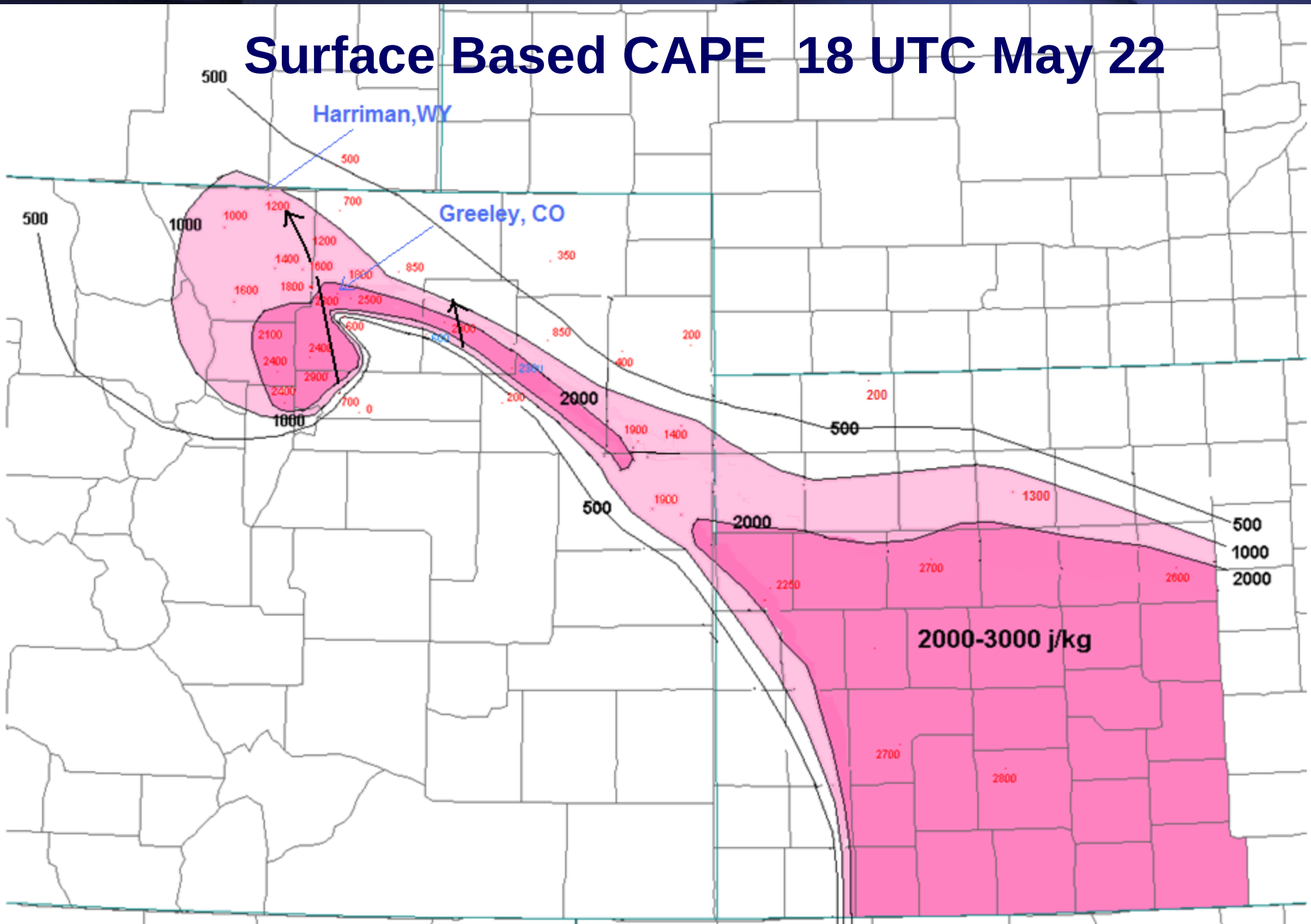
Why Did the Storm Weaken in Larimer County?

The storm suddenly moved into much cooler air (55F) while the elevation changed little. So the potential temperature dropped sharply.

Distribution of CAPE

Surface based CAPE values were calculated from surface observations, raobs (18 UTC Denver sounding) and model soundings.

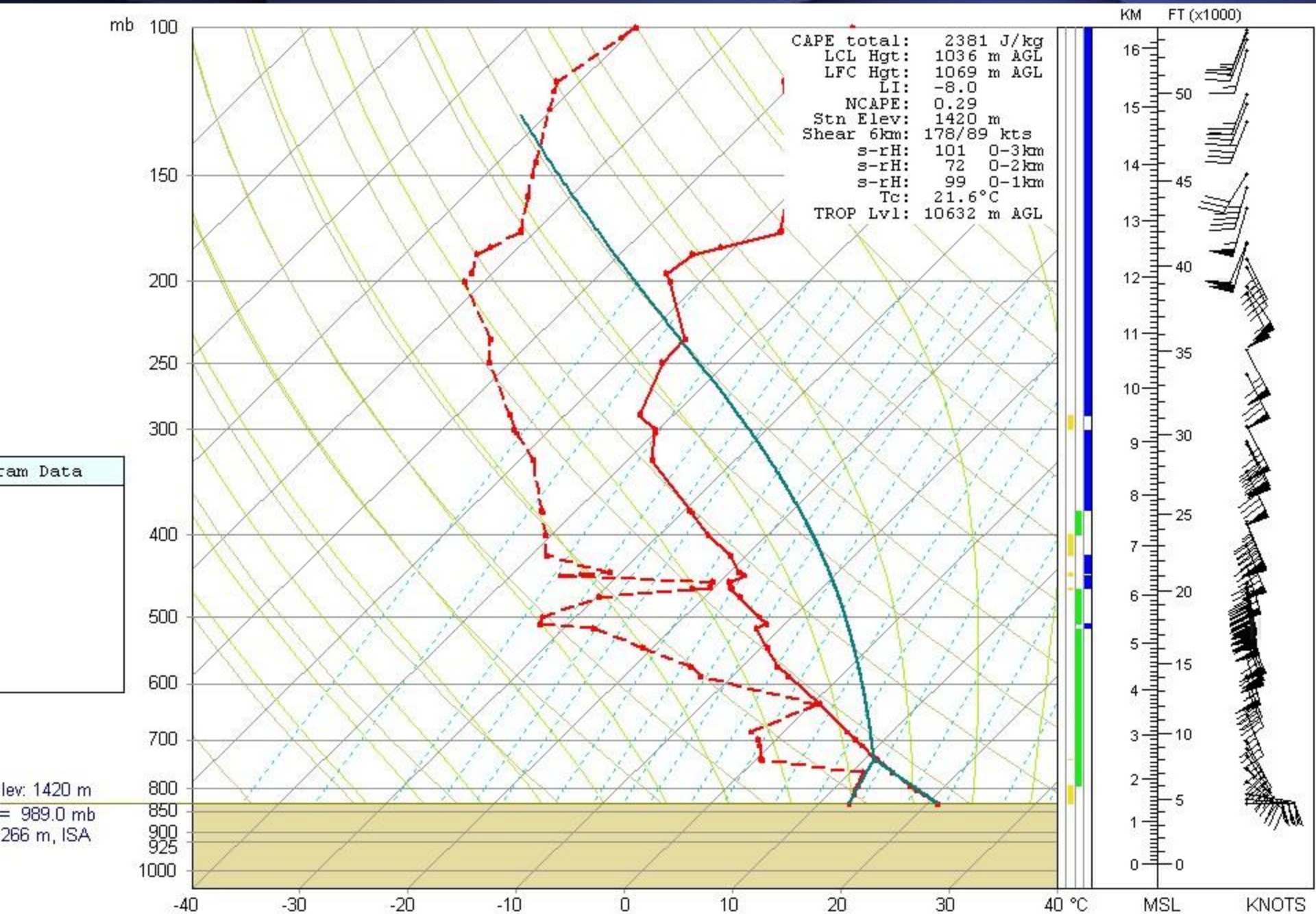
Storm Residence Time in Unstable Airmass



Greeley, CO Sounding at 18 UTC from AWIPS and RAOB

- The 18 UTC Denver sounding was very useful at mid and high levels
- However, the low to mid-level jet (dry intrusion) was just east of Denver and not sampled very well
- The Denver sounding was modified at low levels using the 18 UTC Greeley surface observation

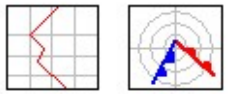
Greeley, CO sounding at 18 UTC (from RAOB)



ram Data

lev: 1420 m
= 989.0 mb
266 m, ISA

Greeley, CO Hodograph at 18 UTC (from RAOB)

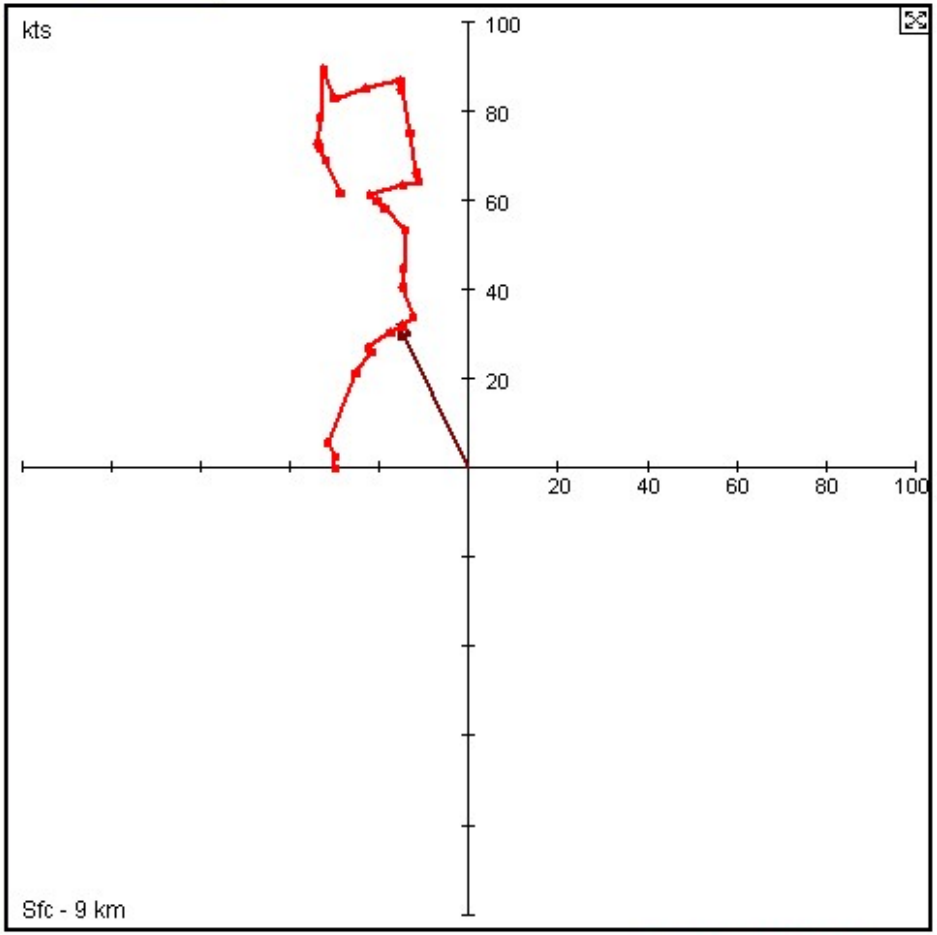


Storm-Motion: 154/36 kts

RESET Method: Manual entry

PRES (mb)	HEIGHT (m) MSL	AGL	DIR / SPD (deg) / (kts)	Ground Relative
257.6	10249	8829	155 / 68	
296.9	9297	7877	155 / 76	
309.2	9019	7599	155 / 79	
312.2	8953	7533	155 / 80	
335.8	8448	7028	157 / 85	
385.4	7475	6055	160 / 95	
387.9	7429	6009	160 / 95	
411.6	6999	5579	160 / 88	
435.1	6590	5170	165 / 88	
455.6	6248	4828	170 / 88	
457.9	6210	4790	170 / 88	
459.7	6181	4761	170 / 86	
467.8	6049	4629	170 / 76	
475.0	5935	4515	170 / 67	
476.9	5905	4485	170 / 65	
487.2	5743	4323	167 / 65	
513.8	5339	3919	160 / 65	
524.0	5188	3768	161 / 63	
530.1	5099	3679	162 / 61	
559.2	4686	3266	165 / 55	
588.2	4290	2870	162 / 47	
604.3	4076	2656	160 / 43	
652.0	3467	2047	160 / 36	
702.7	2857	1437	155 / 35	
717.4	2685	1265	150 / 35	
729.0	2552	1132	150 / 35	
756.0	2247	827	140 / 35	
757.0	2236	816	140 / 34	
783.7	1943	523	130 / 33	
812.2	1638	218	100 / 32	
822.8	1526	106	95 / 30	
833.0	1420	0	90 / 30	

INVERT

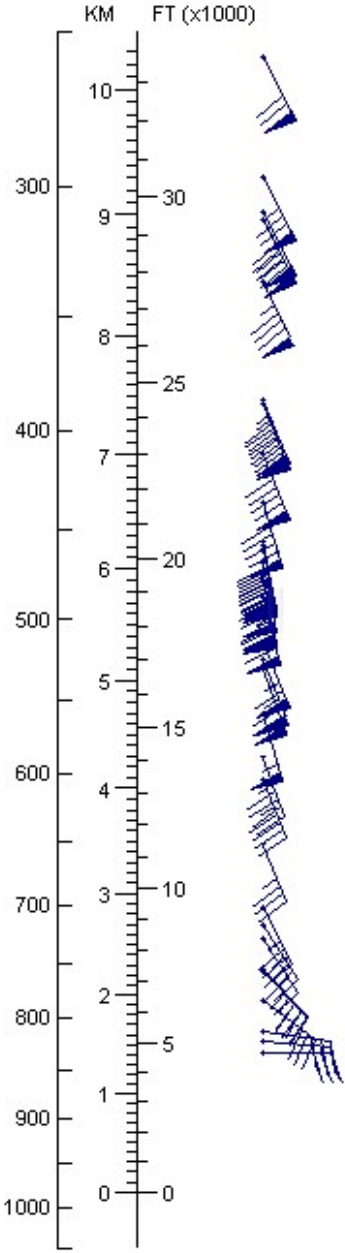


VGP: 0.511 (0-4km)
EHI: .9 (0-2km)
BRN: 11
BRN Shear: 221.4 m/s
s-rH: 47 (0-3km)
s-rH: 56 (0-2km)
s-rH: 58 (0-1km)
Mean Wind: 159/55 kts (0-6km)
Shear: 178/89 kts (0-6km)

Storm Vector

Cursor:
Wind:

Stn Elev: 1420 m



Ground-Relative Winds

OB Config #1:

Harriman, WY sounding at 19 UTC
Method and Data Used

- "Mesowest" hourly temperature observations at Harriman, WY and Lynch, WY
  - Hourly temperatures from cooperative observer 2 miles southwest of Harriman
- Widespread dense fog from Harriman to Vedauwoo indicates that temperatures were about the same as the dewpoints.
- The mid to high-level temperatures were determined from the RUC and Denver 18 UTC sounding.

Harriman, WY sounding at 19 UTC "Mesowest" T/TD Data Used

19 UTC	Elev(ft)	Pres.(mb)	SLP(mb)	T(F)	Td(F)	MR(g/kg)	theta(F)	theta-e(K)
Harriman,WY	7450	754	985	47	47	9.3	89.7	333.3
Lynch,WY	7200	760	985	48	48	9.5	89.4	333.6
Virginia Dale 7 ENE	7000	765	985	48.5	48.5	9.6	88.9	333.7

Theta-E vs Elevation at 19 UTC

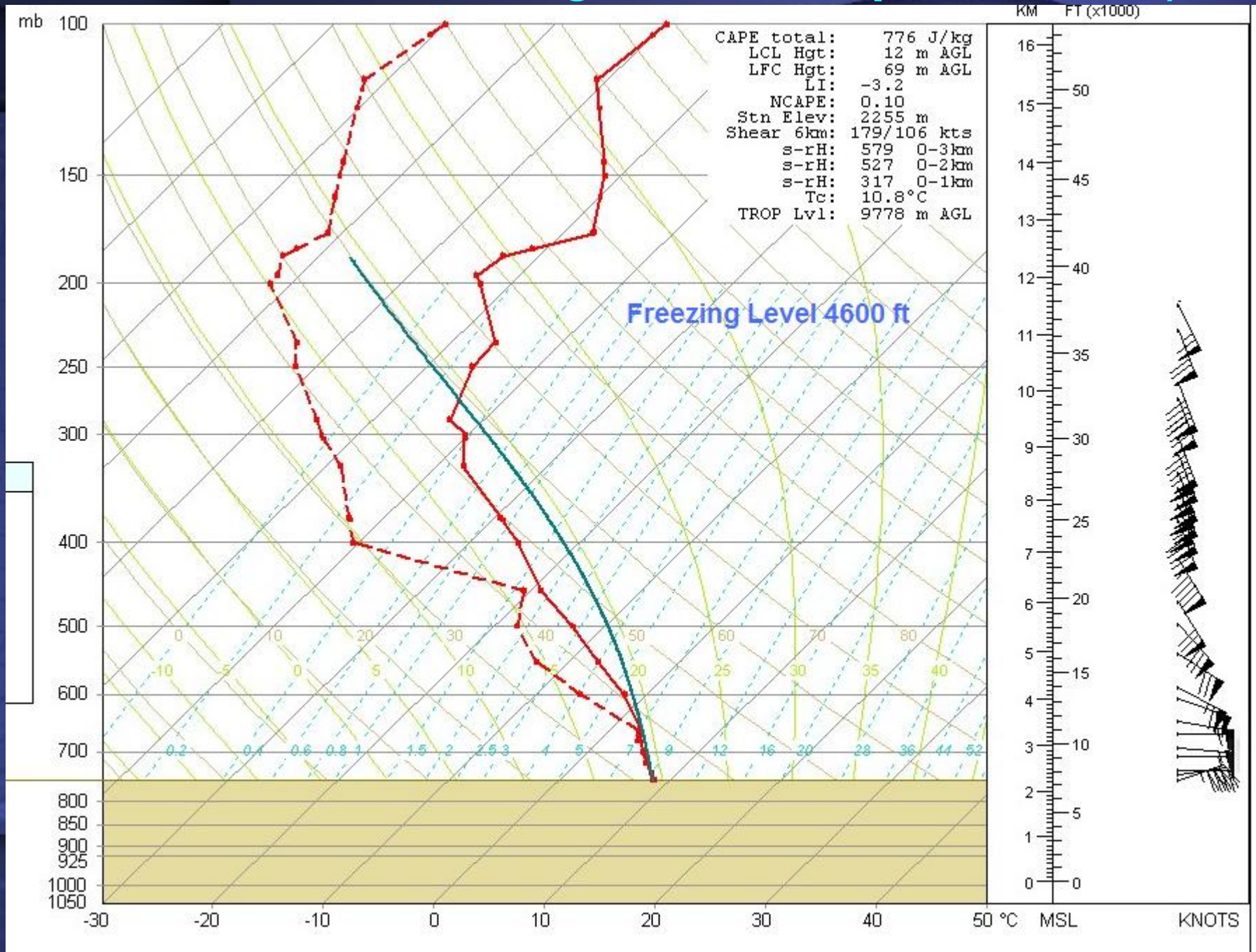
- **Relatively high potential temperature was a large contributor to Theta-e at Harriman!!**

19 UTC	Elev(ft)	Pres.(mb)	SLP(mb)	T(F)	Td(F)	MR(g/kg)	theta(F)	theta-e(K)
Harriman,WY	7450	754	985	47	47	9.3	89.7	333.3
Emkay,WY	6720	772	986	49	49	9.7	88.2	333.8
Nunn	5650	803	983	52.5	52.5	10.6	85,6	334.6
Sterling	3900	865		59	56	11.2	80.9	333.4
Akron	4700	840	990	56	55	11.1	82.3	334.1
Concordia	1500	948	1000	71	61	12.2	79.2	335.3
Scandia	1450	949	1001	69	61	12.2	77	333.9

Harriman, WY sounding at 19 UTC
"Mesowest" Wind Data Used

WYDOT station	14 UTC	15	16	17	18	19	20	21	22
Lynch (7E of tornado at 19 UTC)	09021g26	09020g31	03019g32	08020g26	08034g35	06023g44	07044g44	08023g44	0908g20
Buford (7N of tornado at 19 UTC)	07017g26	06023g26	05029g32	07025g36	05033g42	03045g45	08036g50	07045g45	07011g23

Harriman, WY sounding at 19 UTC (from RAOB)



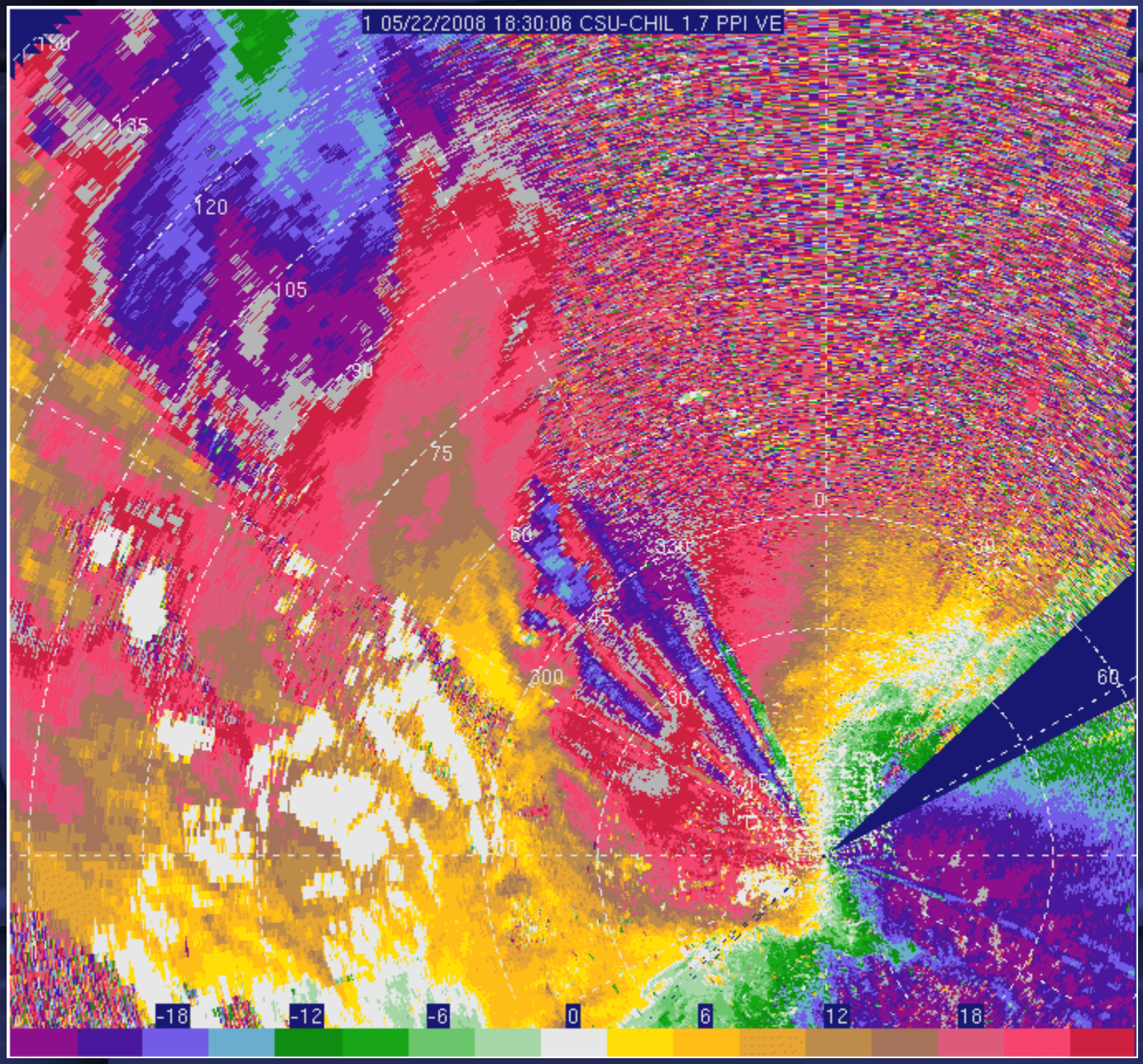
CAPE and Freezing Level near Vedauwoo

- There was a slow decrease in surface based CAPE as the storm moved toward Vedauwoo and beyond.
- A meteorological tower south of Vedauwoo (8200 ft) measured a temperature of 44.5 at 19 UTC.
- Despite the temperature being 3.5F cooler, the theta-e was only slightly lower than at Harriman (333.3K vs 331.8K) since the elevation was 700 ft higher.
- The surface based CAPE was about 600 j/kg with a very low freezing level of 3700 ft.

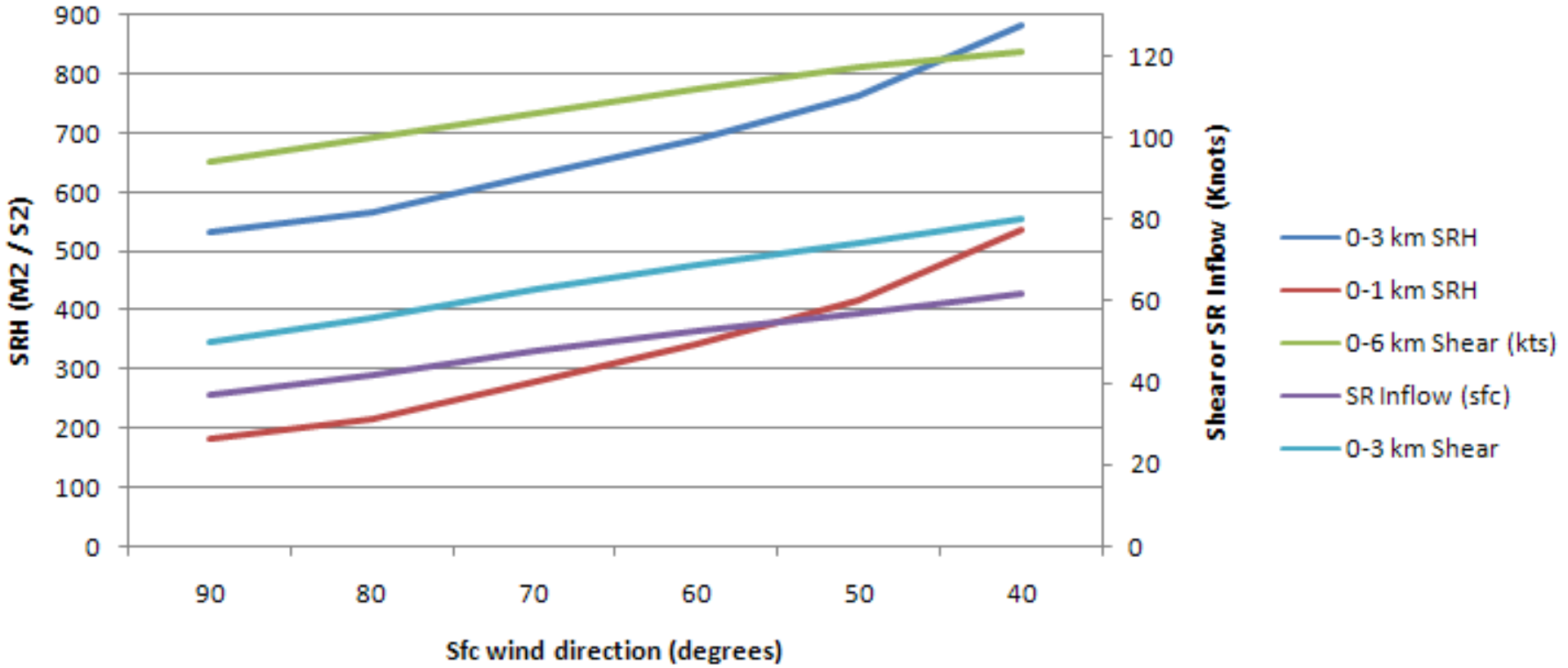
Vertical Wind Shear & SRH for Harriman

- Platteville ,CO profiler was missing after 16 UTC
- Medicine Bow profiler was too far west
- **WSR-88D Cheyenne VAD Wind Profile**
- **WSR-88D Base Velocity**
- **“Mesowest” surface observations**

CSU/CHILL 1.7° Base Velocity Loop



Vertical Wind Shear and SRH for Various Wind Directions at Harriman at 19 UTC



Harriman, WY Hodograph for 19 UTC with Storm Motion 146 at 42 kts and SFC Wind 070 at 35 kts

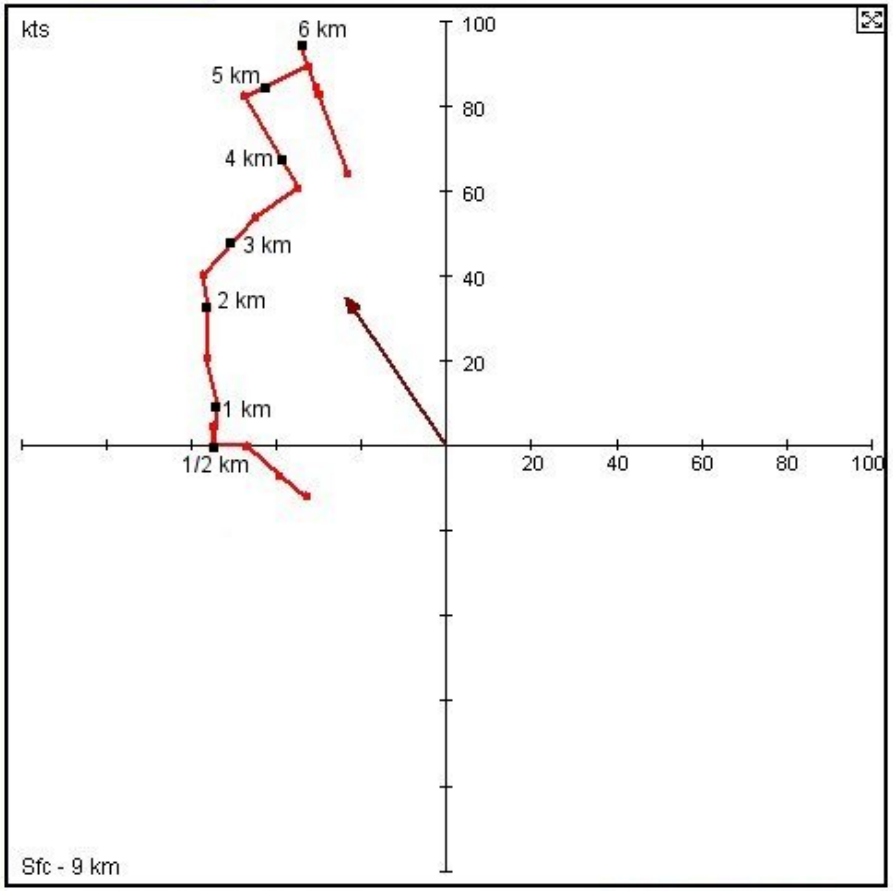
PRES (mb)	HEIGHT MSL	(m) AGL	DIR / SPD (deg) (kts)
226.5	11084	8829	160 / 68
261.4	10132	7877	160 / 88
272.5	9854	7599	160 / 90
302.5	9150	6895	160 / 95
316.0	8850	6595	160 / 100
332.4	8500	6245	160 / 100
346.9	8200	5945	160 / 100
362.1	7900	5645	160 / 100
377.8	7600	5345	160 / 95
418.6	6855	4600	150 / 95
469.8	6000	3745	150 / 70
498.4	5555	3300	140 / 70
538.8	4955	2700	125 / 70
589.1	4255	2000	120 / 65
608.3	4000	1745	110 / 60
645.8	3520	1265	100 / 55
667.4	3255	1000	90 / 55
692.4	2955	700	95 / 55
709.5	2755	500	90 / 55
736.0	2455	200	90 / 47
744.9	2355	100	80 / 40
754.0	2255	0	70 / 35

Ground Relative

INVERT

Storm-Motion: 146/42 kts

RESET Method: Manual entry

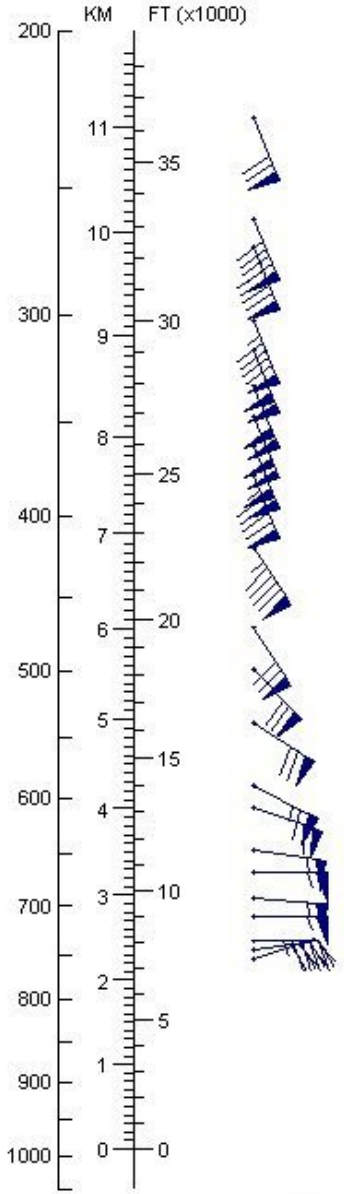


VGP: 0.409 (0-4km)
EHI: 2.2 (0-2km)
BRN: 2
BRN Shear: 336.1 m/s
s-rH: 627 (0-3km)
s-rH: 560 (0-2km)
s-rH: 280 (0-1km)
Mean Wind: 136/67 kts (0-6km)
Shear: 179/106 kts (0-6km)

Storm Vector

Cursor:
Wind: --

Stn Elev: 2255 m



RAOB Config #1:

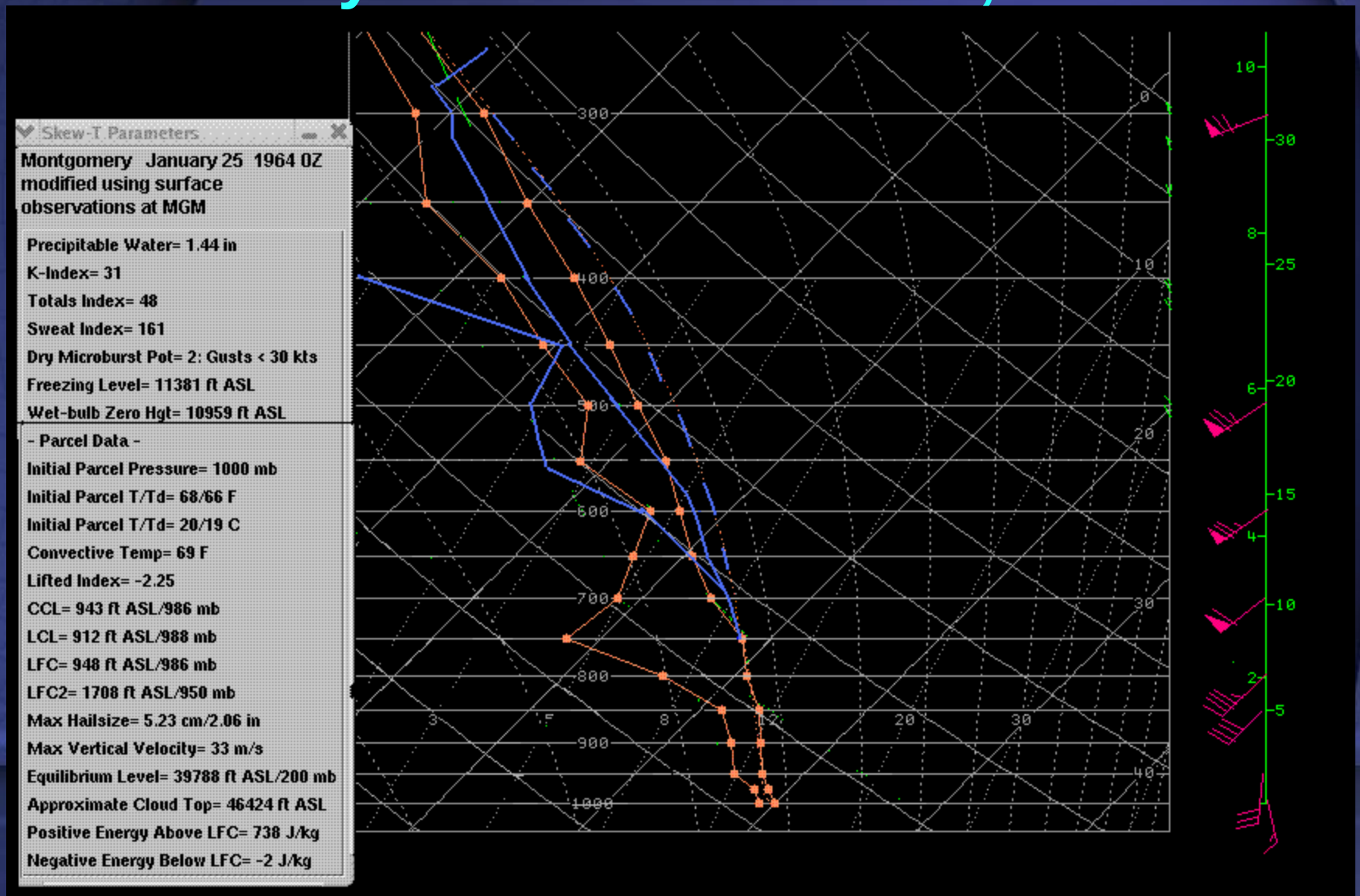
January 24 1964 Montgomery, AL
vs
May 22 2008 Harriman, WY

- Relatively high potential temperature was a larger contributor to Theta-e at Harriman

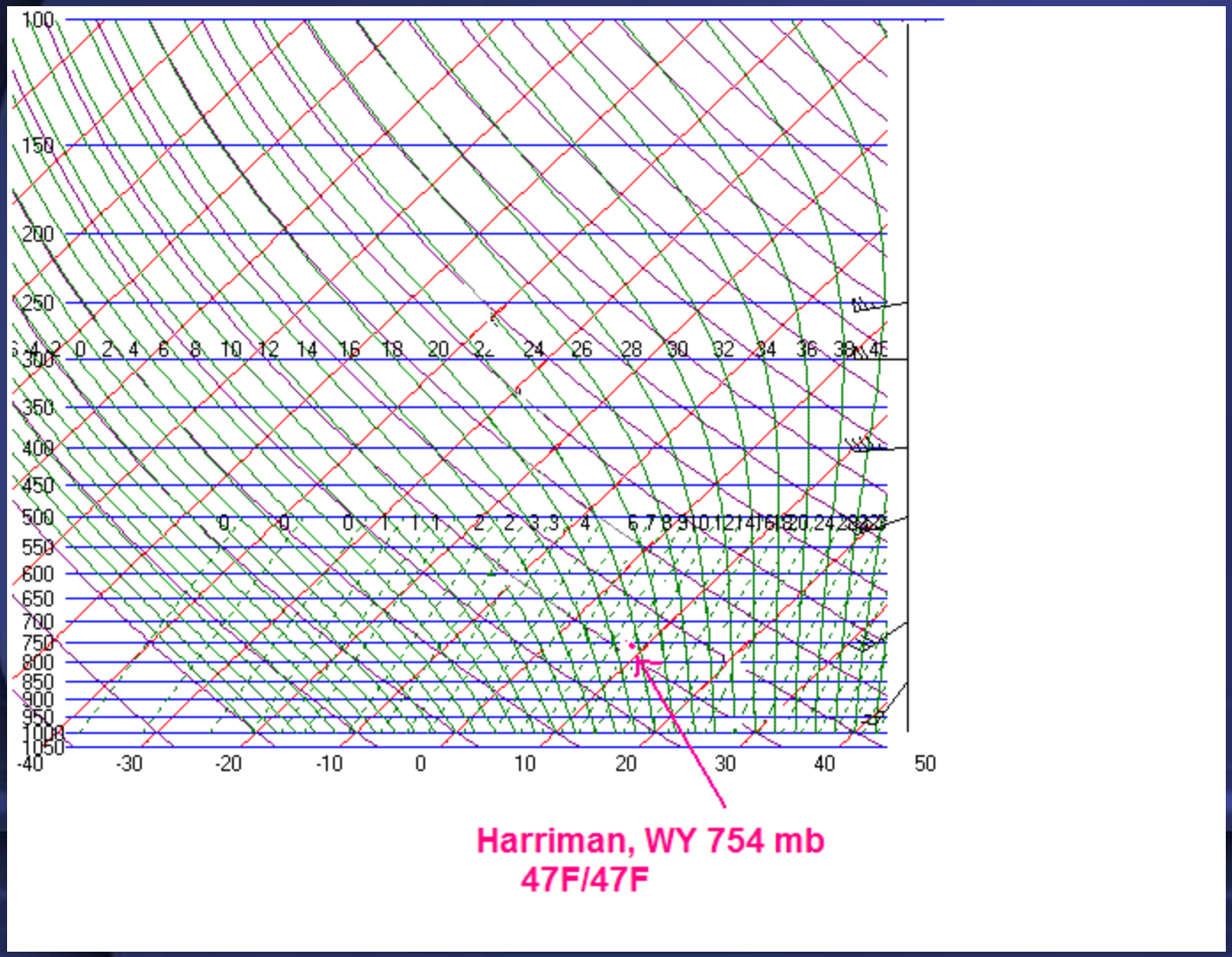
- Relatively high mixing ratio was a larger contributor to Theta-e at Montgomery

		Elevation (ft)	Pres.(mb)	SFC (°F)	SBCAPE j/kg	MR (g/kg)	Theta (°F)	Theta-e (K)
01-24-1964	Montgomery	22	1000	68/66	738	13.9	68	332.7
05-22-2008	Harriman	7450	754	47/47	776	9.2	90 *	333.3

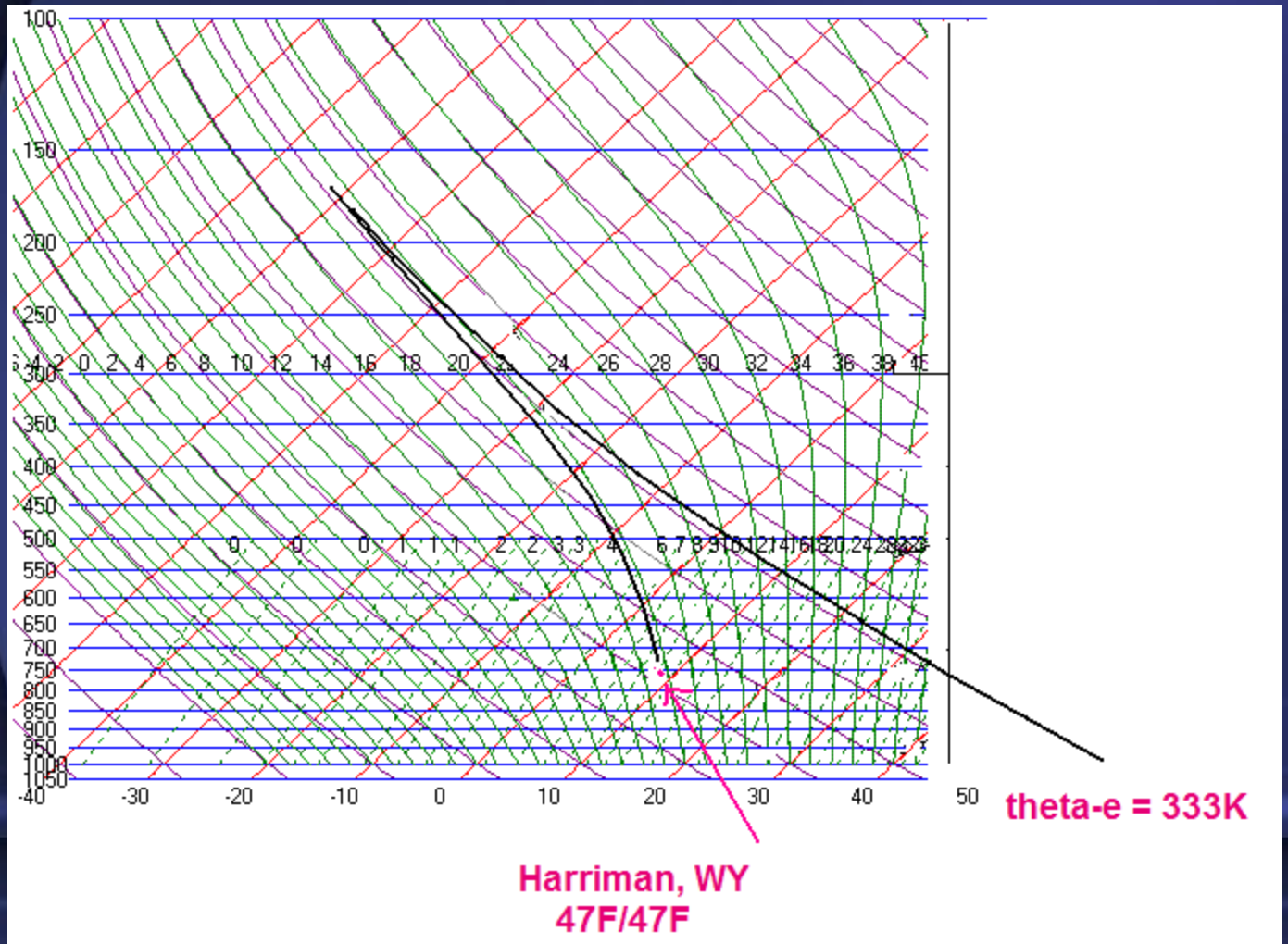
January 24 1964 Montgomery, AL
vs
May 22 2008 Harriman, WY



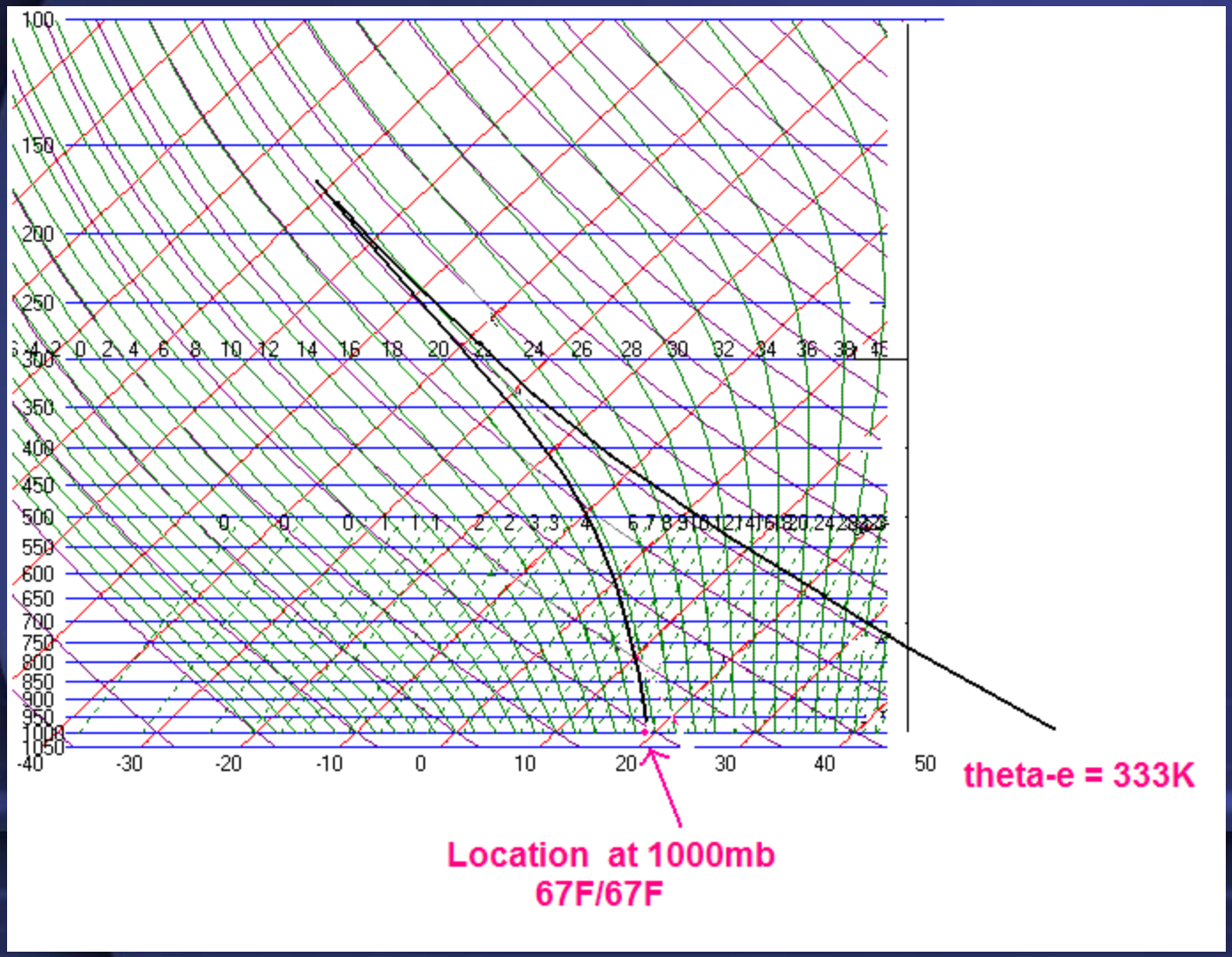
Harriman, WY Surface Observation at 19 UTC
T/TD = 47F/47F



Harriman, WY Theta-E at 19 UTC
T/TD = 47F/47F



1000mb Location Theta-E at 19 UTC
T/TD = 67F/67F



Conclusions

- Perhaps the highest elevation tornado to cause significant property damage occurred on May 22 2008 ?
- CAPE distribution was important for longevity of storm.
- Surface boundaries were crucial for the Colorado tornado.
- LCL/LFC heights were low in Colorado and near the ground in Wyoming.
- Baseball sized hail occurred at 8400 ft on the Laramie Range with only 600-700 j/kg CAPE. Extreme shear and 3700 ft freezing level likely compensated for the marginal surface based CAPE.

Web Site

http://www.bangladeshtornadoes.org/UScases/052208/22may2008terrain.html