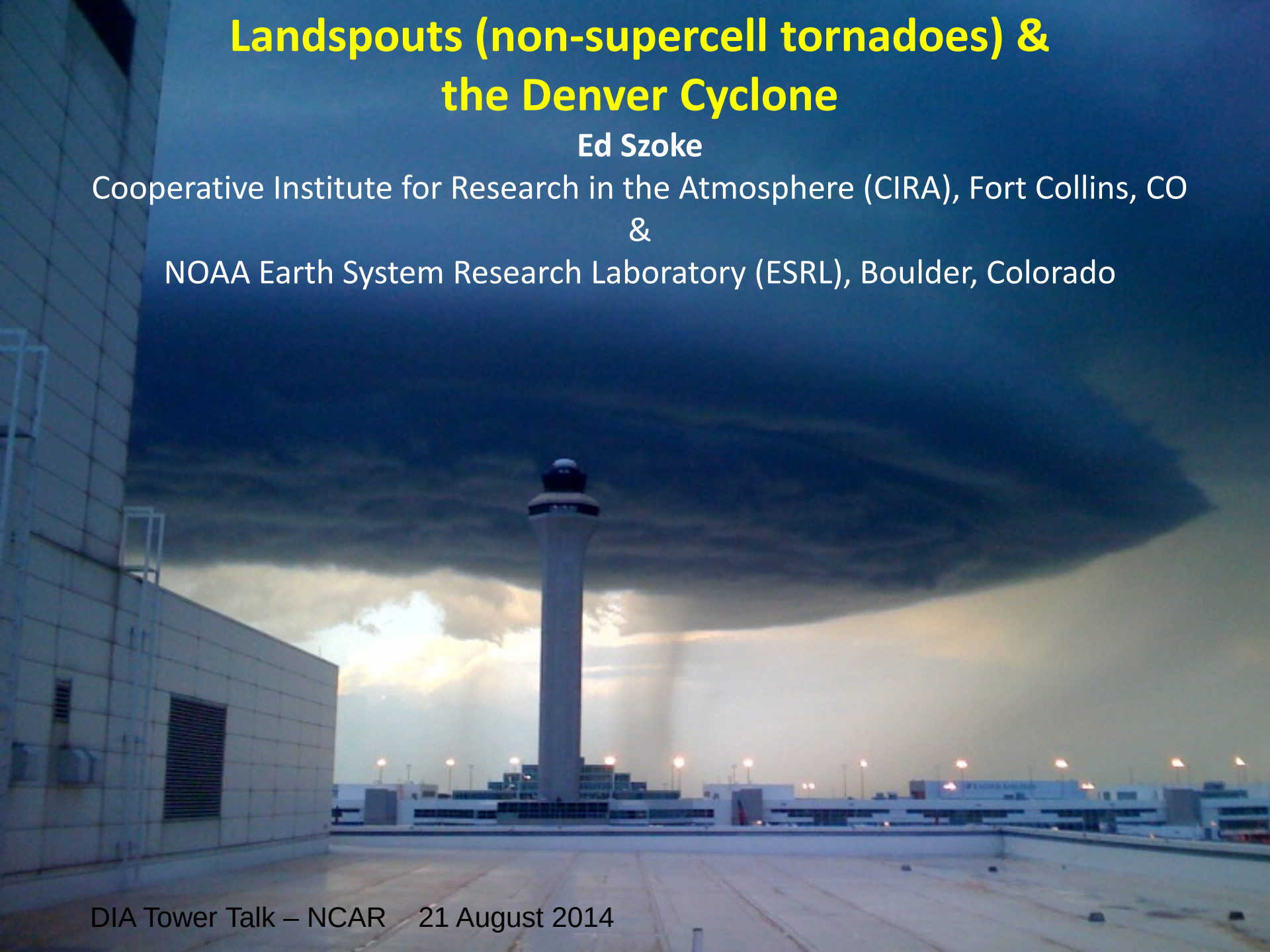
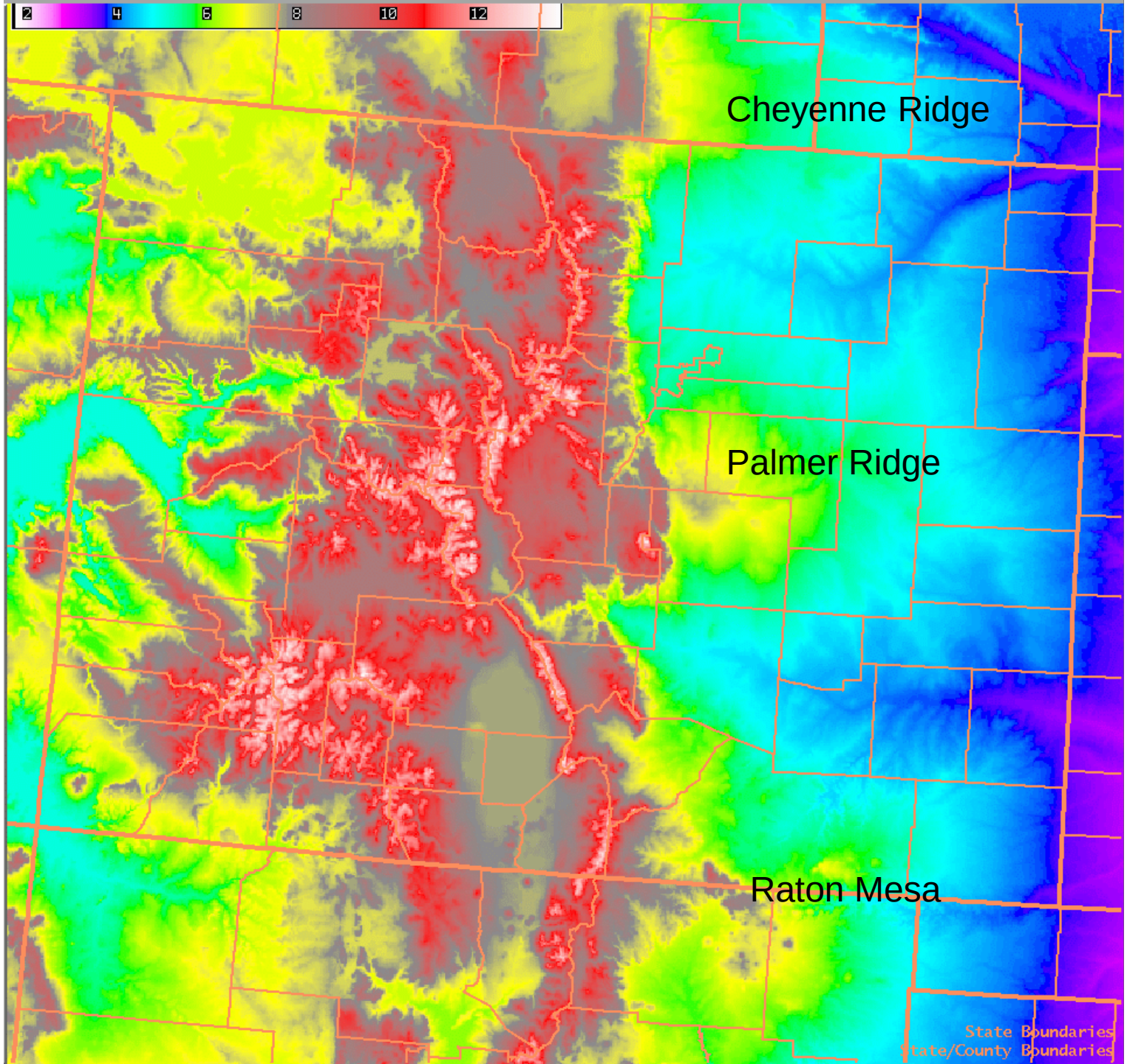
Landspouts (non-supercell tornadoes) & the Denver Cyclone

Ed Szoke
Cooperative Institute for Research in the Atmosphere (CIRA), Fort Collins, CO
&
NOAA Earth System Research Laboratory (ESRL), Boulder, Colorado



DIA Tower Talk – NCAR 21 August 2014

- What the DCVZ is and why it is important
- Cases – mostly non-supercell tornadoes associated with the Denver Cyclone (DCVZ) – to demonstrate the variety we see
  - 3 June 1981 – tornadoes WEST of Stapleton
  - 26 July 1985 – Erie tornado – goes across I-25
    - DCVZ boundary displaced more to the west
  - 15 June 1988 – the big one!
    - 4 tornadoes in/near Denver in ~30 min, tower evacuated (Stapleton). F2 to even some F3 damage.
  - 6 June 1997 Boulder tornado
  - 4 Oct 2004 – landspoutfest near DIA
    - 11 tornadoes reported in 44 minutes just west of DIA
  - 16 June 2013 – DIA tornado
    - tornado moves to the NW across runway and LLWAS


2
4
6
8
10
12
Cheyenne Ridge
Palmer Ridge
Raton Mesa
State Boundaries
State/County Boundaries

Schematic of the Denver Cyclone

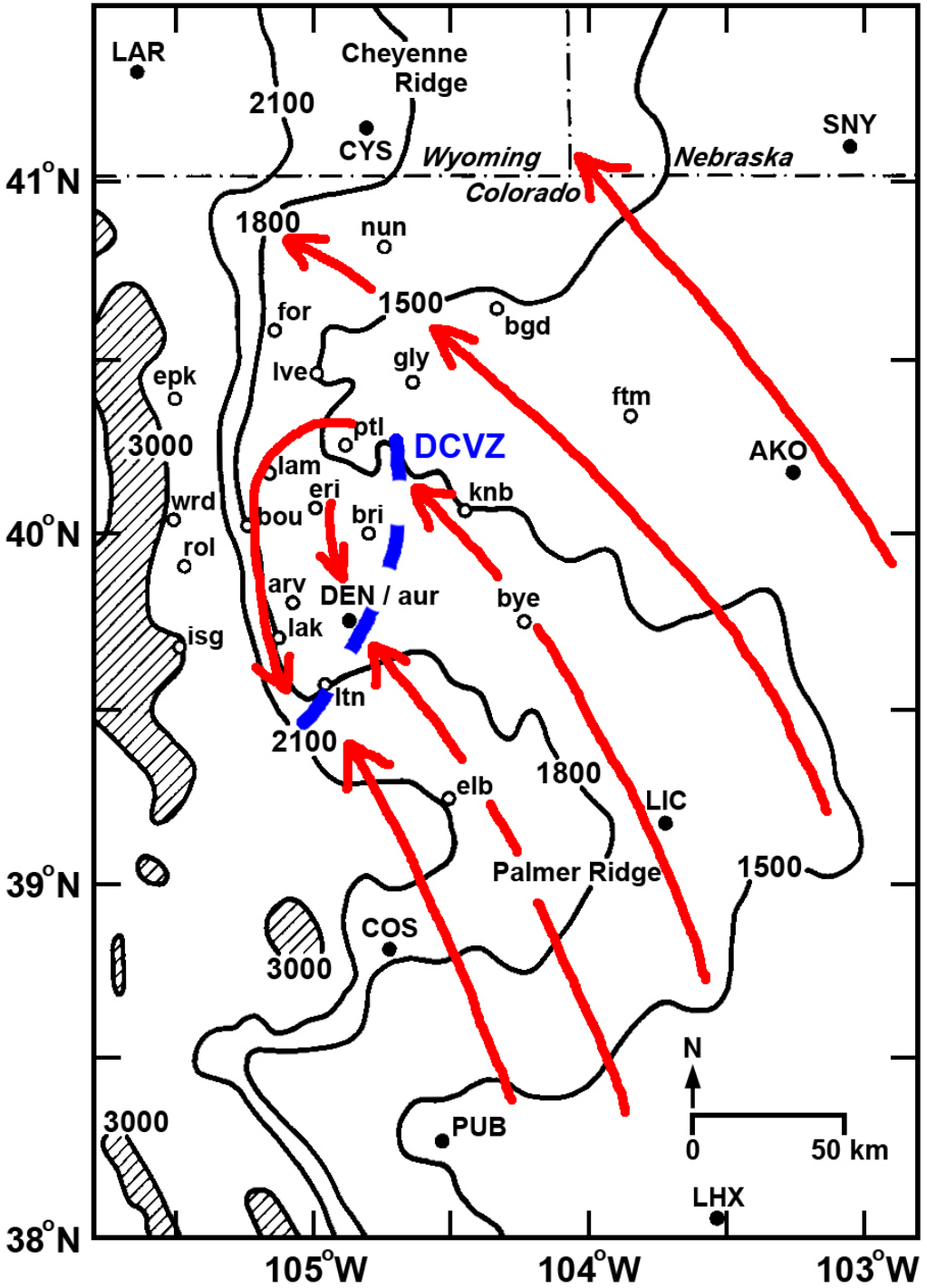
South to Southeast flow passing over the Palmer Ridge under conditions with some (enough) lower level stability results in a downstream turning of the wind.

This forms a zone where the winds come together...often this zone is over DIA.

The zone can remain stationary or move very slowly, and as a result

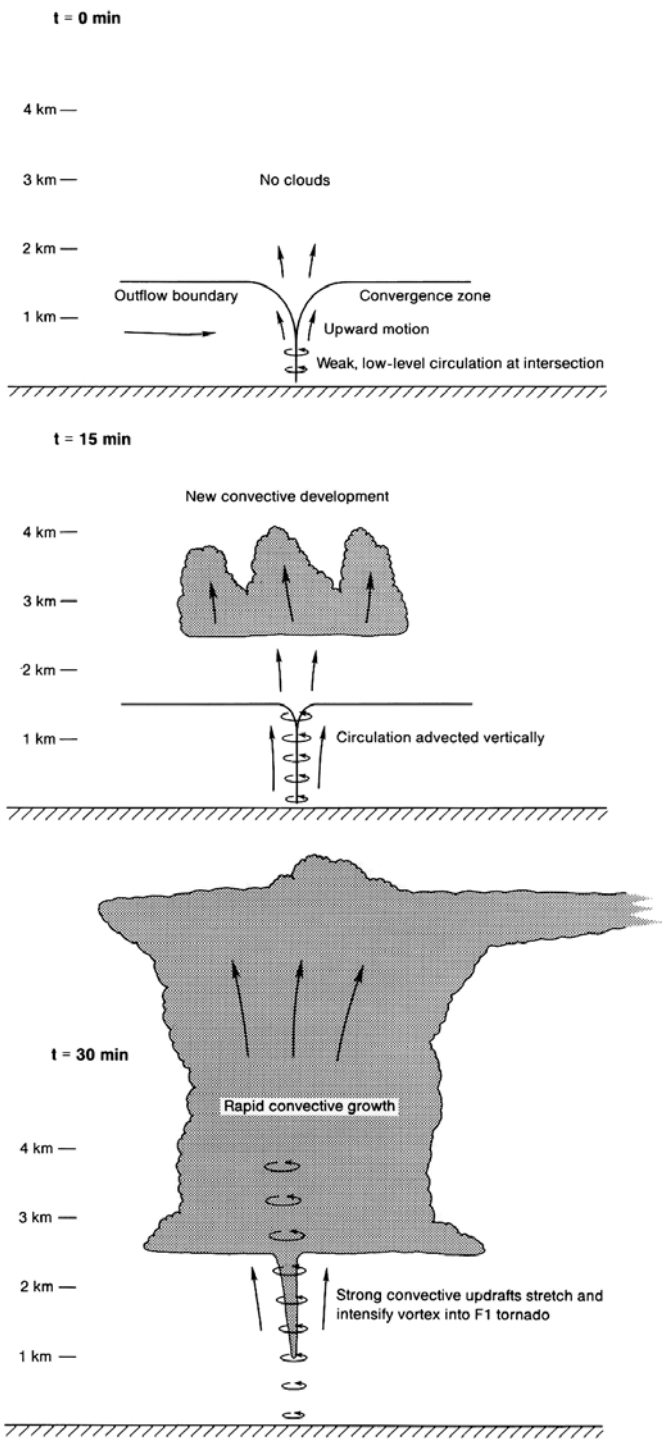
1) the local environment is modified (deepening moisture) to increase the local chance of a storm

2) small scale circulations (vorticity) can form at low levels along the convergence zone (hence called the Denver Convergence-Vorticity Zone or DCVZ)



How to make a non-supercell tornado

1) Low level vertical circulation along the DCVZ (can be present without clouds and for hours)
2) Essentially have the source for a tornado IF the circulation can tighten
3) It CAN tighten if the updraft of a growing cloud/cell is positioned over the low-level circulation
4) And if this happens you get a non-supercell tornado
5) Weaker and shorter lived in general than supercell tornadoes but we've seen up to F3 (EF3) and lasting 20 minutes or more
6) But no pre-existing mesocyclone so harder to predict

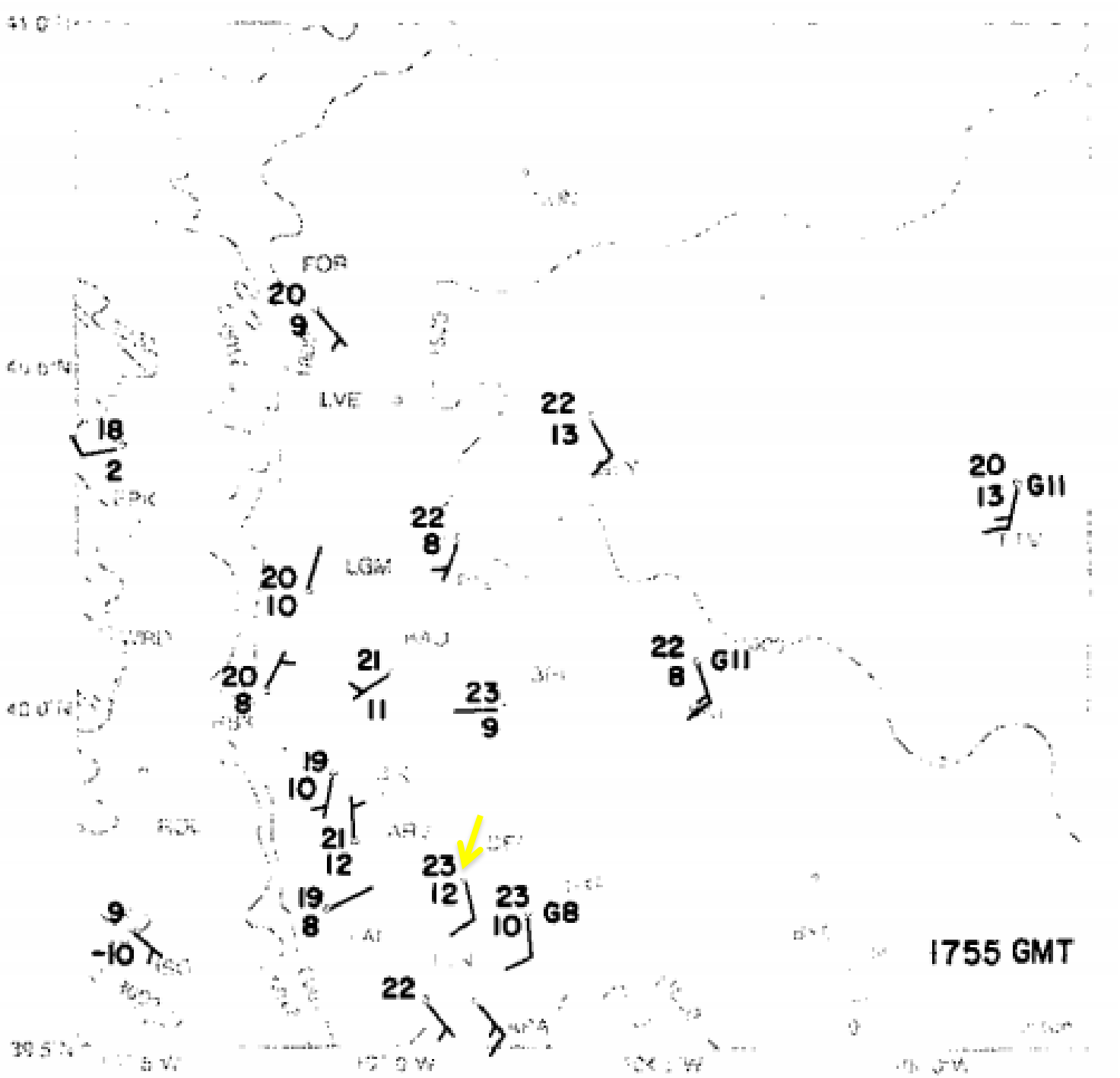


Example 1: Denver tornadoes of 3 June 1981

- Quick look (pre-dates Doppler radar availability here)
- More of a supercell
- But passes over the DCVZ
- Which in this case was located WEST of the old airport

NOAA/PROFS mesonet plot at 1755z (1155 MDT) on 3 June 1981

Arrow points to the old Stapleton Airport location.
Weak DCVZ is located just west of the airport at this time. Temperatures and dew points are in ^{o}C.



NOAA/PROFS mesonet plot at 1950z (1350 MDT) on 3 June 1981

Radar echoes are from the Limon WSR-57 (a test Doppler radar was supposed to start from near the airport on 1 June but was delayed until 5 June!). We can see outflow near and west of I-25 moving east from the foothills storms. The DCVZ still lies west of the airport, essentially right over the city of Denver.

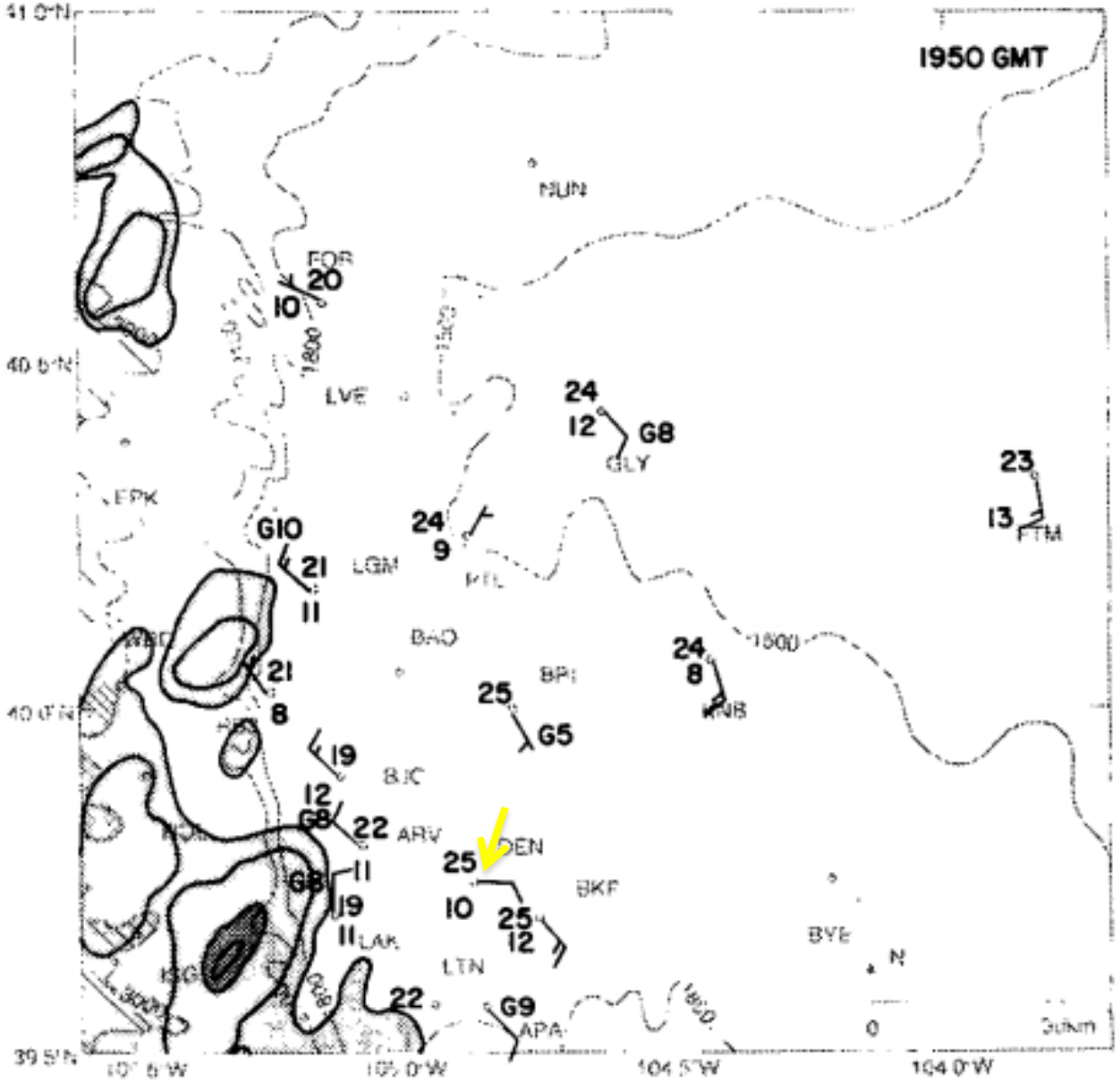
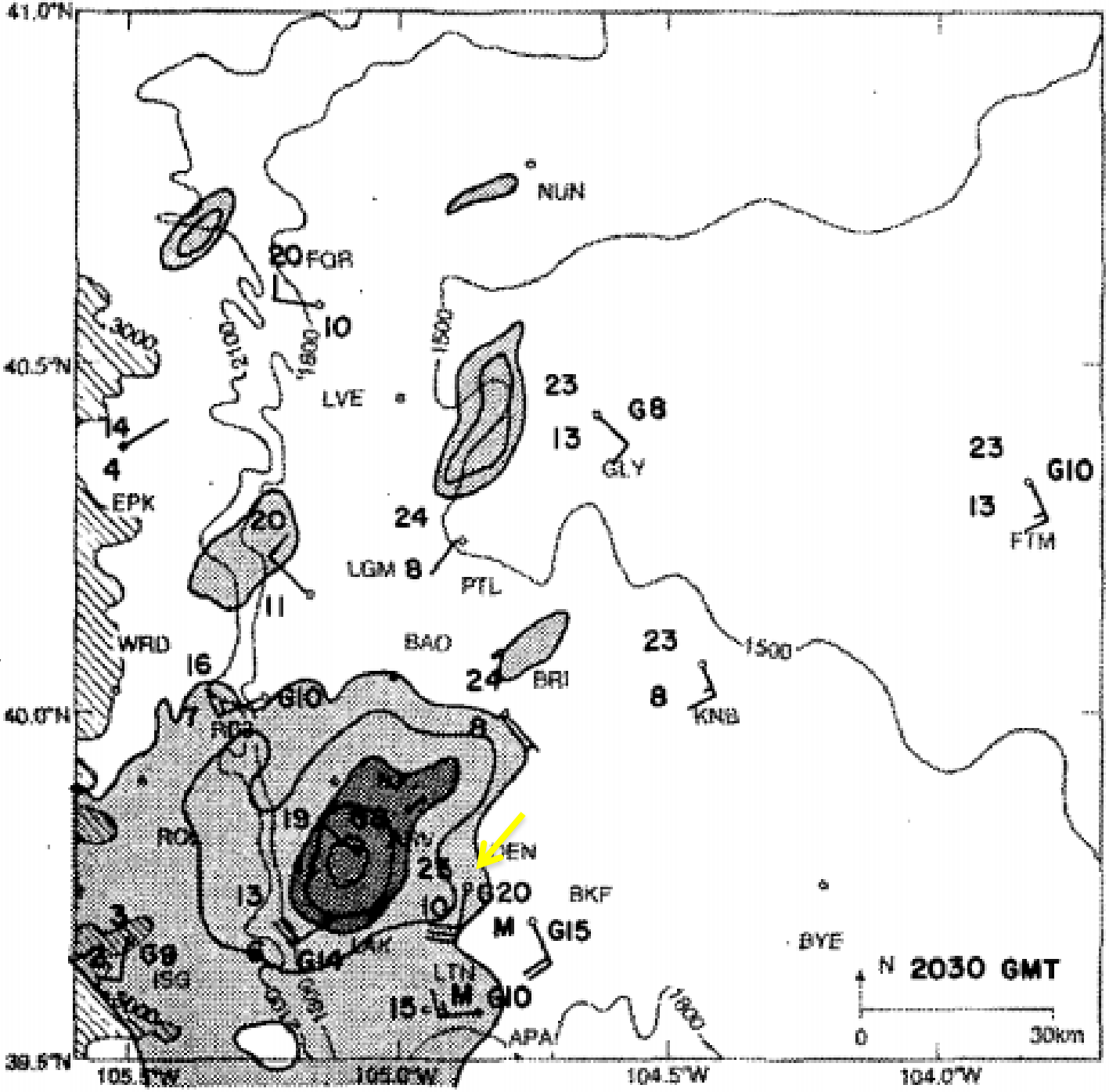


FIG. 11. Surface plot for 1950 GMT 3 June 1981. Radar echoes are from Limon (LIC) radar 1° elevation PPI, contoured at the intensity levels listed in Table 1. Echoes of level 3 or greater are shaded darker.

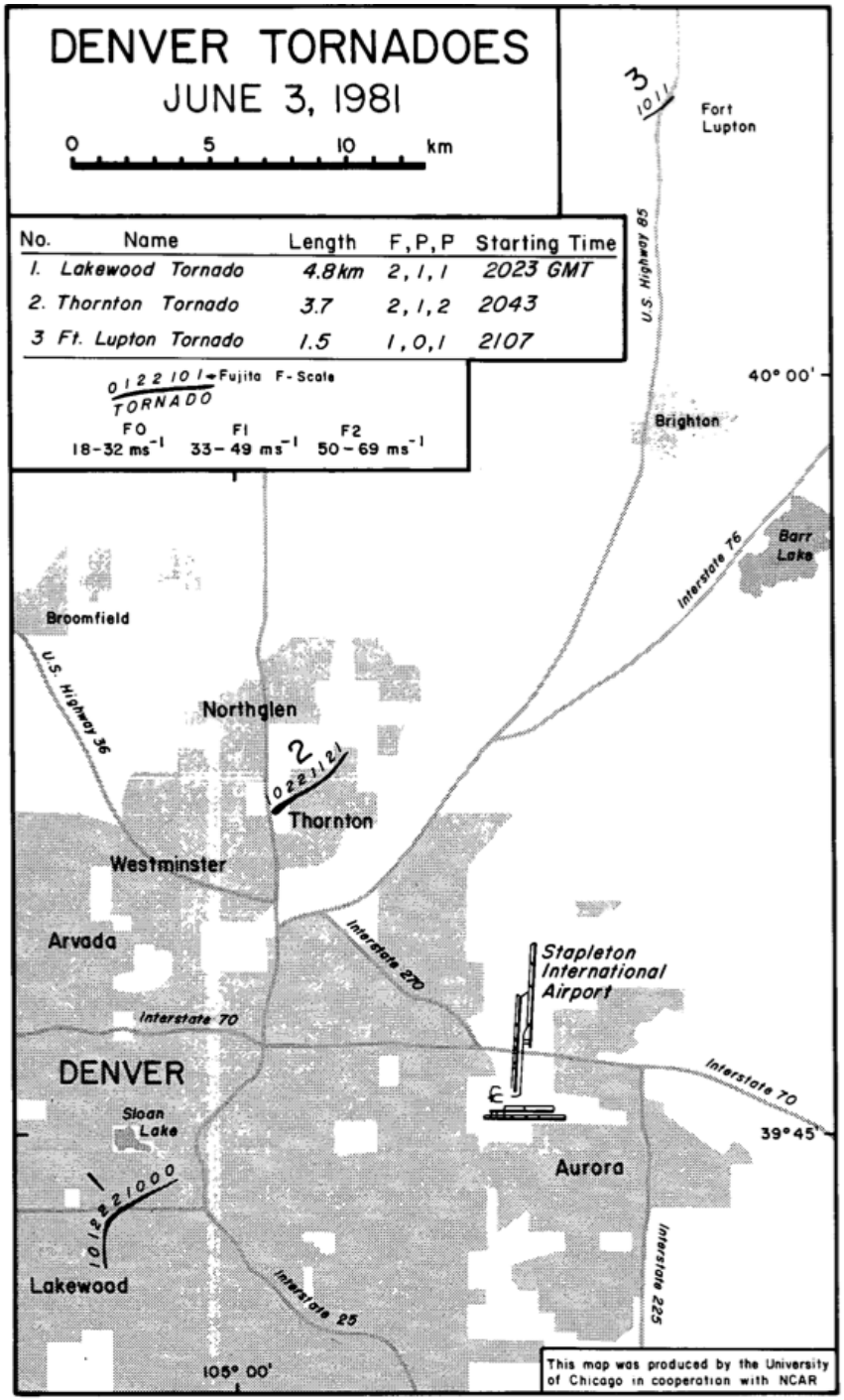
NOAA/PROFS mesonet plot at 2030z (1430 MDT) on 3 June 1981

The tornadic storm (in this case likely a supercell) moves off the foothills to the northeast and passes right over the DCVZ. Did the convergence zone play a role in the subsequent tornadoes? (Or...stated another way, would this storm have produced tornadoes without the DCVZ which it happened to move over?).



3 June 1981

FIG. 2. Photograph of F2 damage from the Thornton tornado.



3 June 1981

FIG. 18. Photograph of the second tornado in a Thornton neighborhood.

Rocky Mountain News 4 Jun 1981

Residents in Thornton area describe terror from the sky

Cat vanishes, owner survives

Roy Fouts thanks God he didn't go the way of his cat.

Fouts, 54, a longtime Thornton resident, said he was chatting with his wife on the telephone Wednesday when the lights went out and his roof disappeared.

Then the cat flew through the hole where the roof had been.

Something was up.

But Fouts had no idea it was the most severe tornado activity to hit the Denver area in years. The Denver FM station he'd been listening to had reported only scattered thundershowers.

Still, he was terrified. He jumped down, clinging to his carpet, as the storm sucked him into the air. He said his feet were off the floor but he didn't lose his hold on the rug.

Fouts, of 1030 Locust Place, said he didn't realize there had been a tornado until a beam crashed down on his back and rain fell on his head.

Alex Mollendor stared at the debris in his yard and groped for words to describe the terror that struck from the sky.

"It was just a twisting monster, that's all," said Mollendor, 54. "I don't know how to explain it right now."

Mollendor was in his home at Corona and Elm streets, Thornton, when a tornado hit about 3 p.m. Wednesday. Later he was mystified by the debris in his yard. "I don't know whose it is," he said.

Also in the yard was Mollendor's camper trailer, overturned. On it was a metal tag that said "Bless This Mess."

Nearby, a telephone pole was tipped at a 30-degree angle.

Across the street, another camper trailer had been picked up by the twister,

Editor's note: Reporting for this article was by Norman Draper, Louis Kilzer and Sharon Stewart. It was written by Karen A. Bailey.

smashed against a roof and thrown about 50 feet, shearing off several trees on the way. All through the neighborhood, power lines lay across streets and alleyways

Officials were confused Wednesday evening about the number of twisters that struck the city. Thornton Police Chief William D. Franks said he thought a single

The areas, which were cordoned off to keep looters out, were along northbound streets between West 88th Avenue at York Street and West 88th Avenue at Washing-

But Fouts had no idea it was the most severe tornado activity to hit the Denver area in years. The Denver FM station he'd been listening to had reported only scattered thundershowers.

Still, he was terrified. He jumped down, clinging to his carpet, as the storm sucked him into the air. He said his feet were off the floor but he didn't lose his hold on the rug.

several cars had been smashed together by the twister.

"And then I saw one of the cars was my parents'," Cordova said. "I ran to the car and they weren't there. I drove to the hospital like a maniac."

At Valley View Hospital and Medical Center, Cordova's parents were treated for minor injuries and released.

Hospital officials said 40people came to the hospital for treatment. Most were

Example 2: The Erie, Colorado I-25 non-supercell tornado of 26 July 1985

- One of the earliest Doppler radar studies of the life cycle of a non-supercell tornado
- Typical environment – no other severe weather occurred
- Nice example of how it often takes an interaction to produce the spin-up
  - In this case an outflow boundary from weak foothills/mountain convection intersecting the DCVZ

Vertical wind shear on 26 July 1985

The very weak vertical wind shear is a lot like that found in the tropics (GATE sounding).

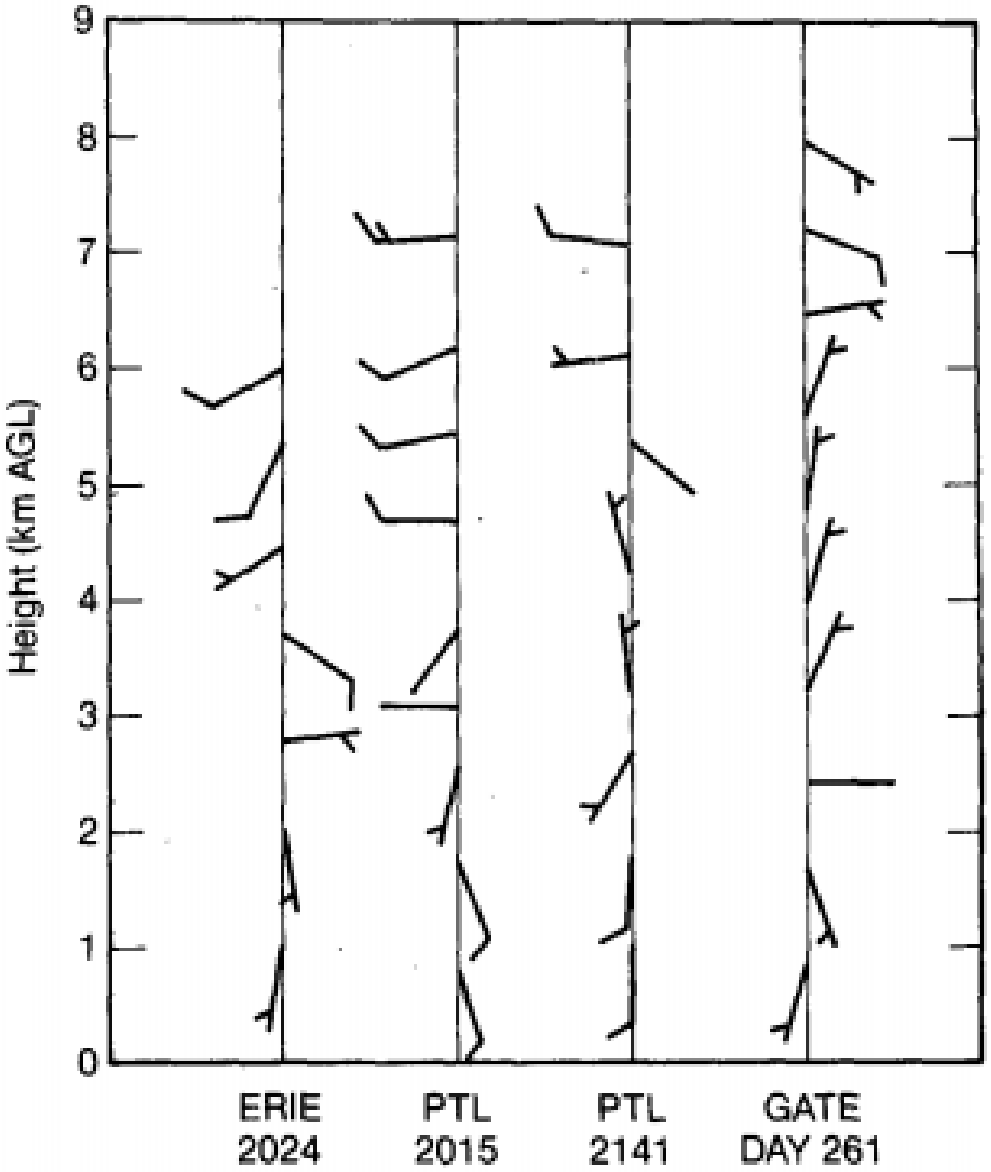
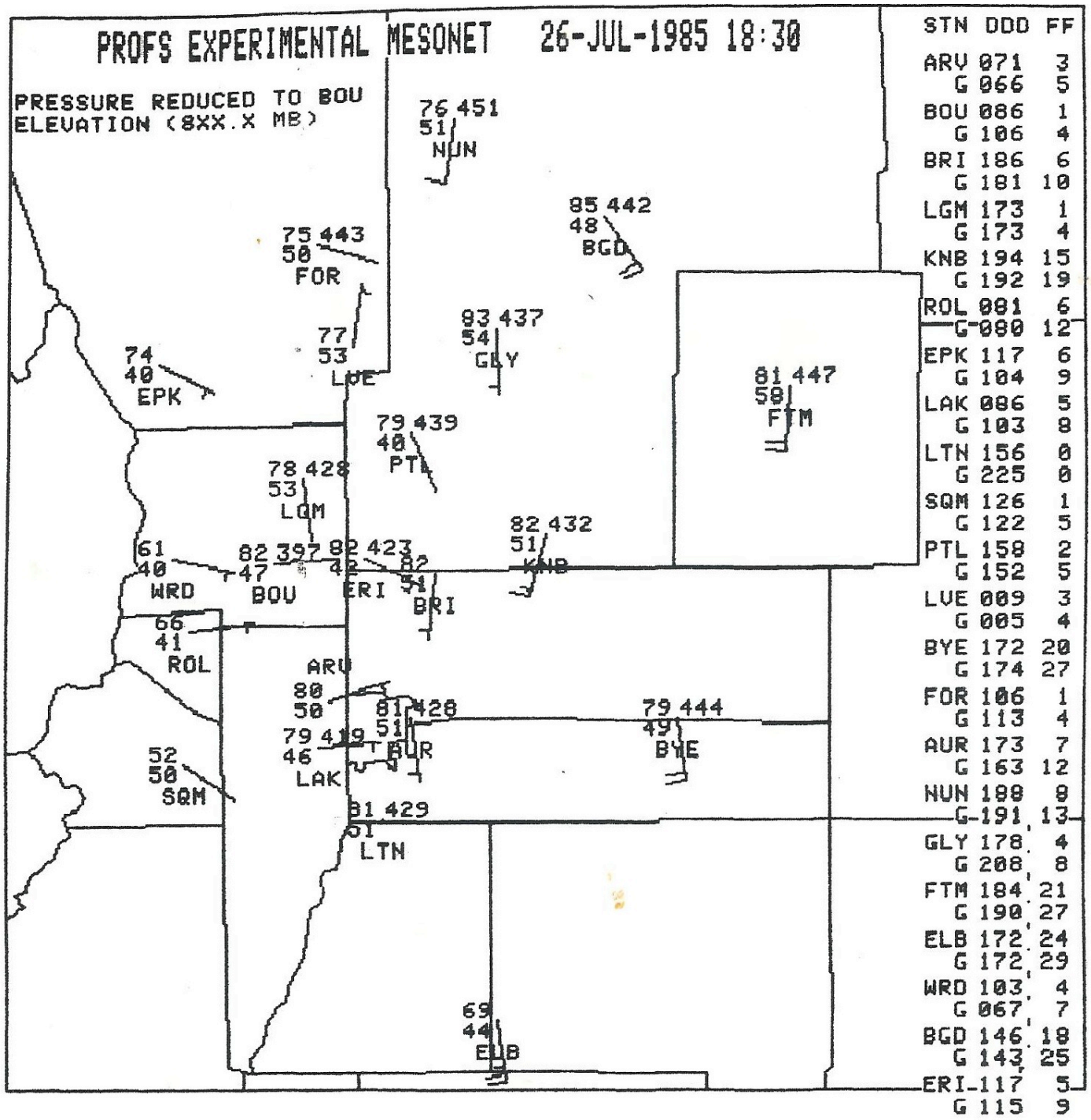


FIG. 2. Tornado proximity winds from Erie, Colorado at 2024 UTC and Platteville, Colorado at 2015 and 2141 UTC. Waterspout-proximity winds from GATE day 261 are also shown (from Simpson et al. 1986). A half barb and full barb represent winds of 2.5 and 5 m s^{-1}, respectively. Heights are in kilometers AGL.

The then-experimental "PROFS Mesonet" 1830z (1230 MDT) on 26 July 1985

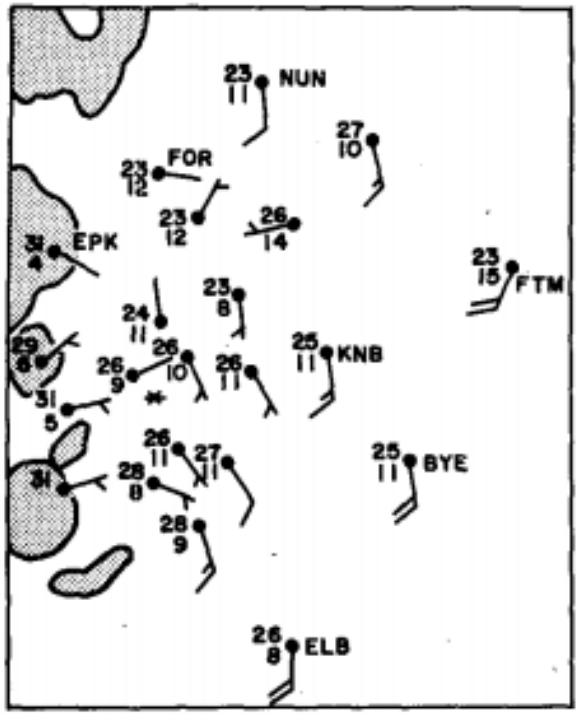
Robust southerly flow on the plains, a somewhat disorganized DCVZ near and east of I-25.

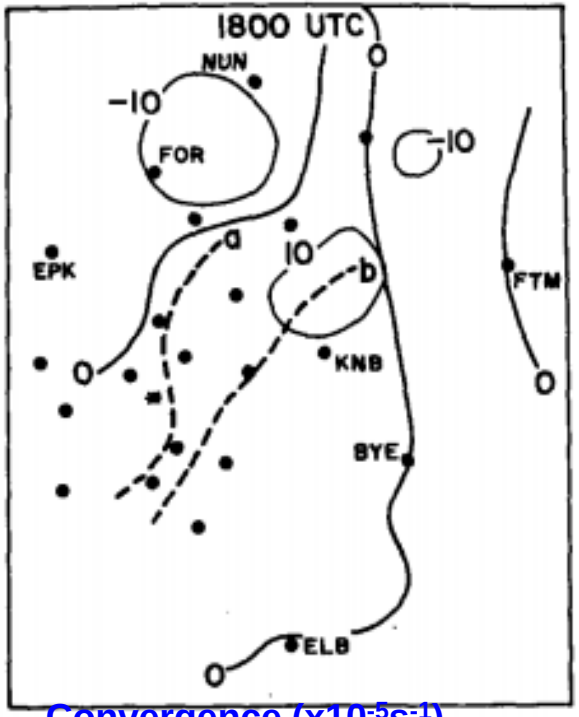
No DIA back then!

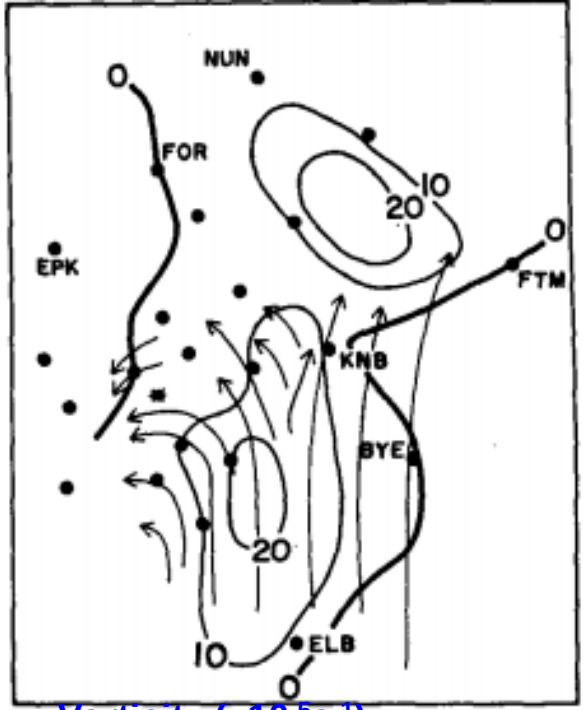


Noon

1400 MDT

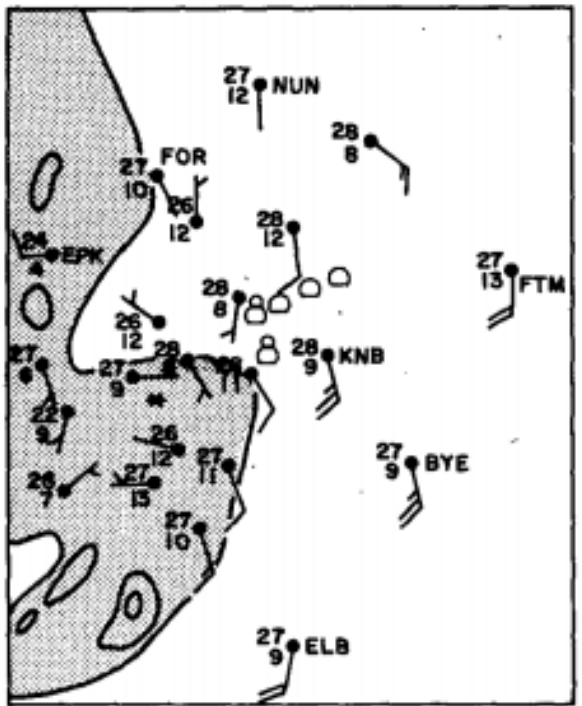


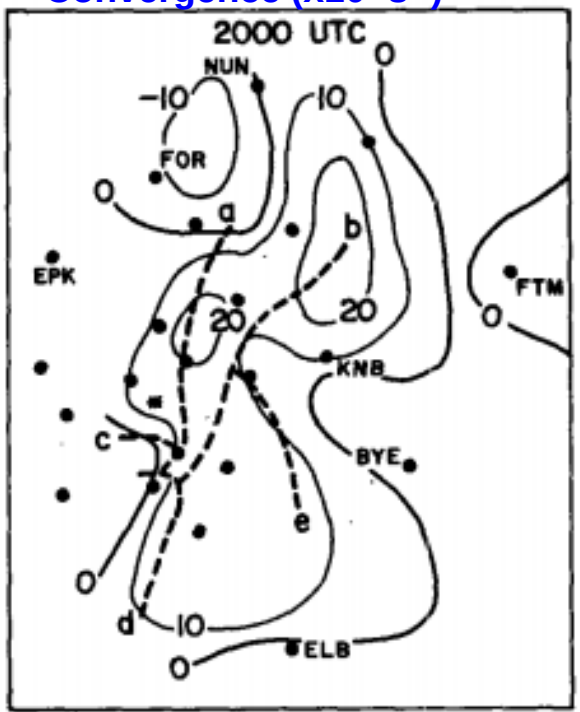


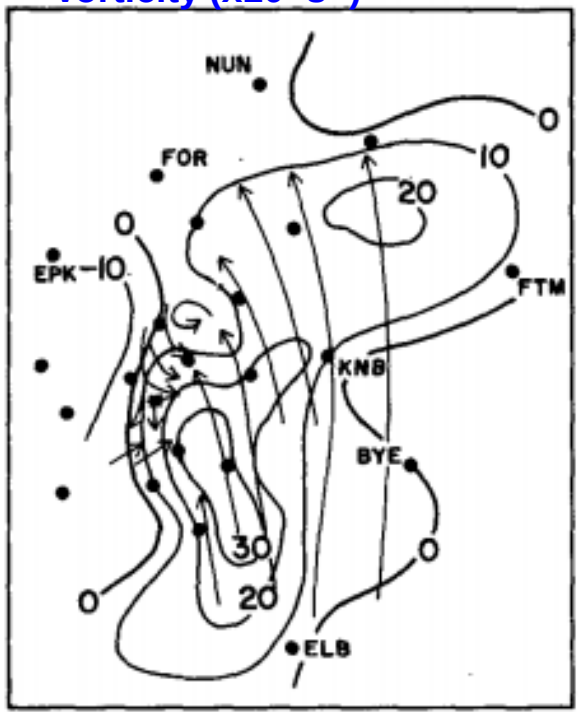


Convergence ($x10^{-5}s^{-1}$)

Vorticity ($x10^{-5}s^{-1}$)

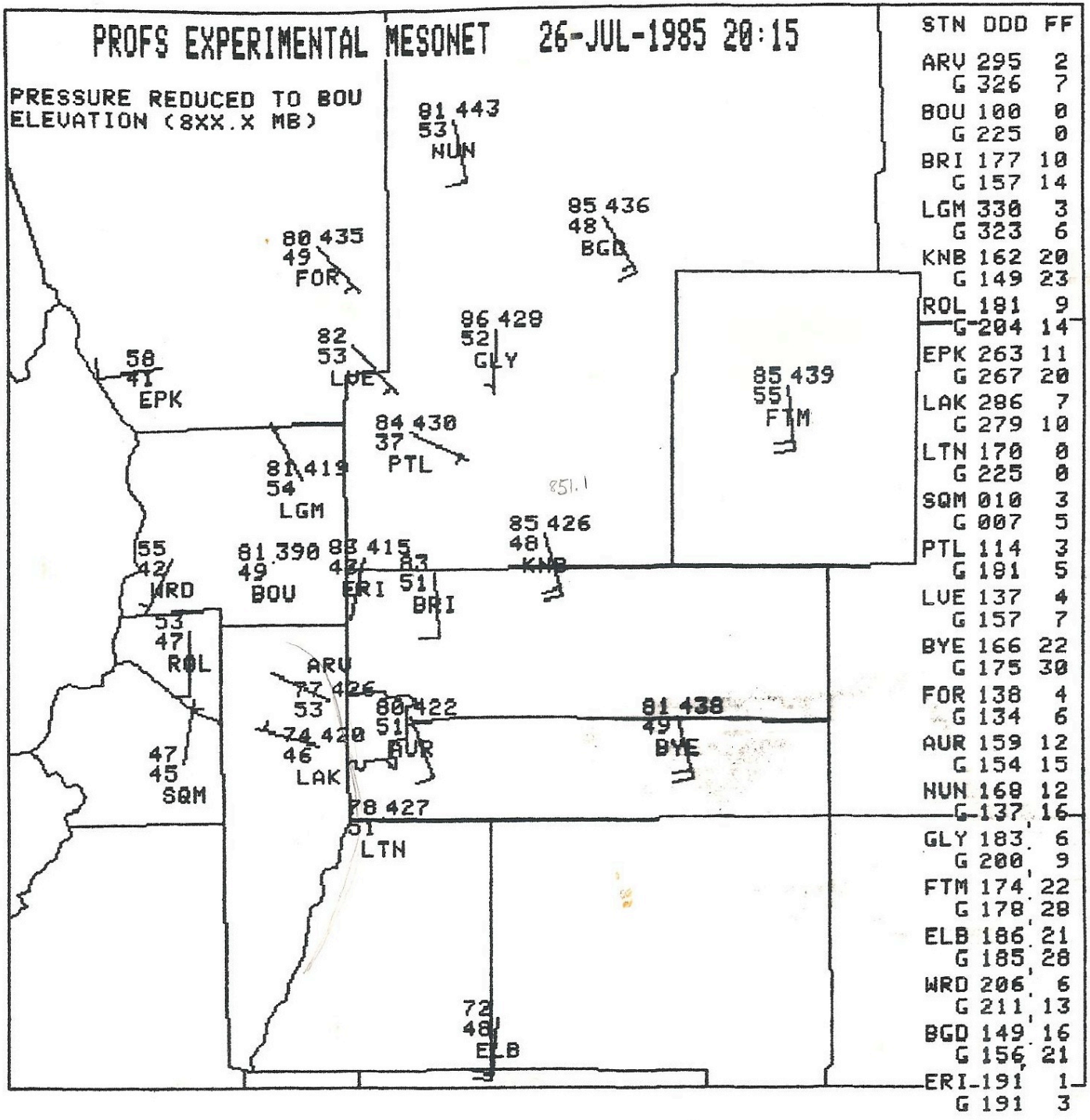




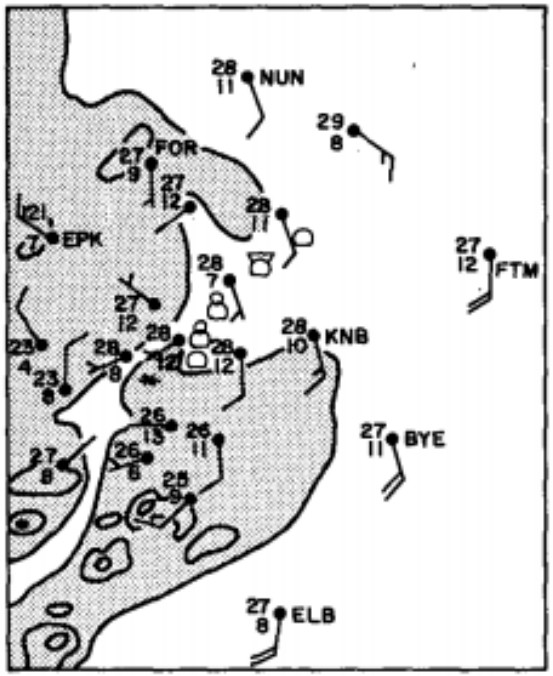


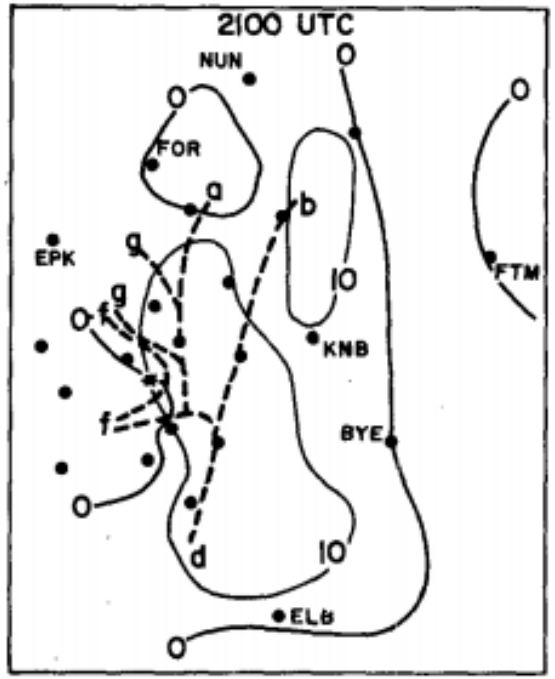
The then-experimental "PROFS Mesonet" 2015z (1415 MDT) on 26 July 1985

Some of the boundaries are pretty subtle and only trackable using the Doppler radar data.

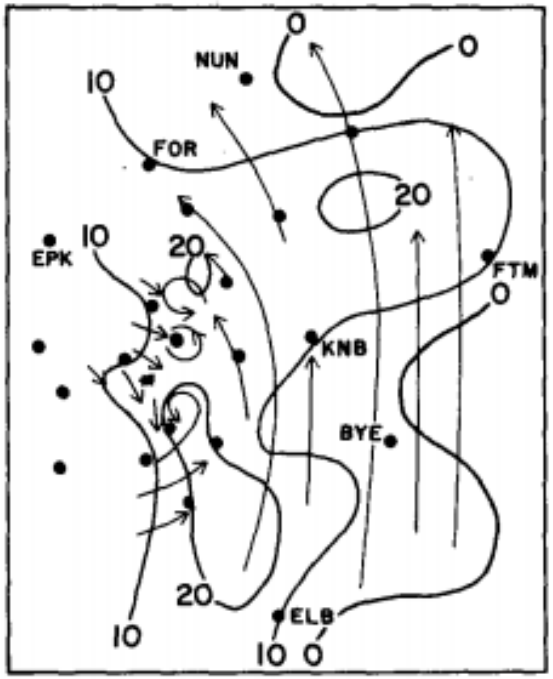


1500 MDT



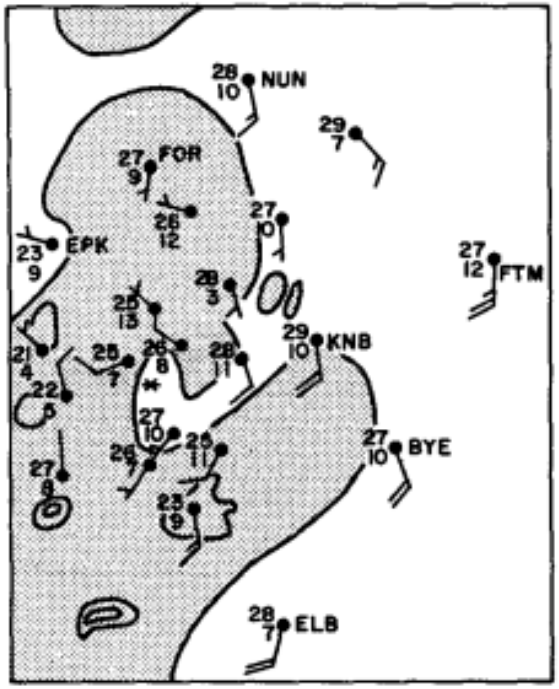


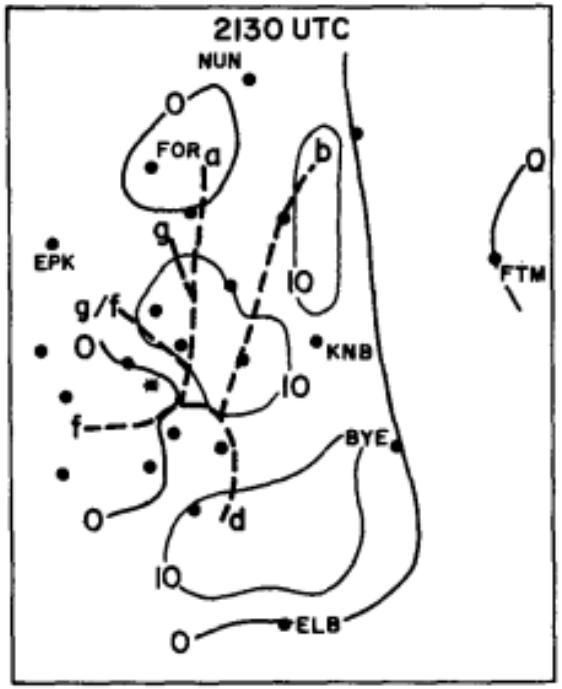
Convergence ($x10^{-5}s^{-1}$)

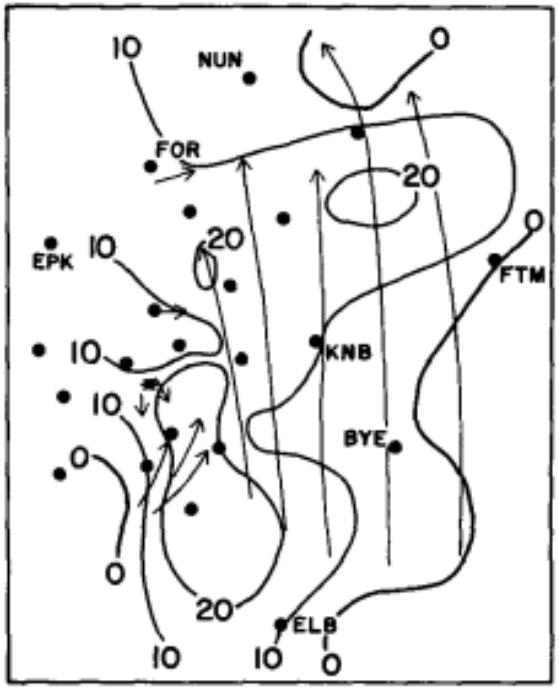


Vorticity ($x10^{-5}s^{-1}$)

1530 MDT

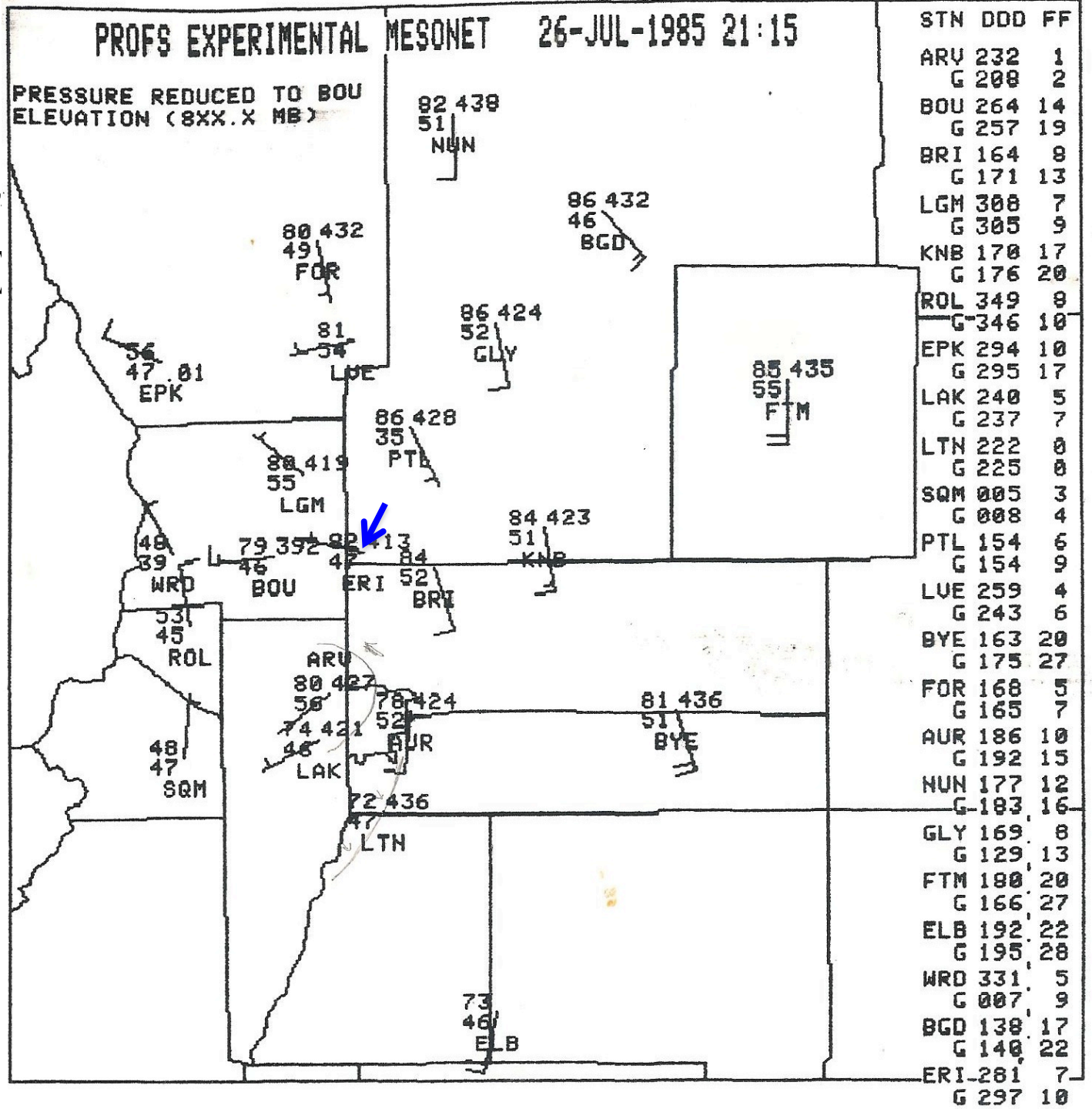




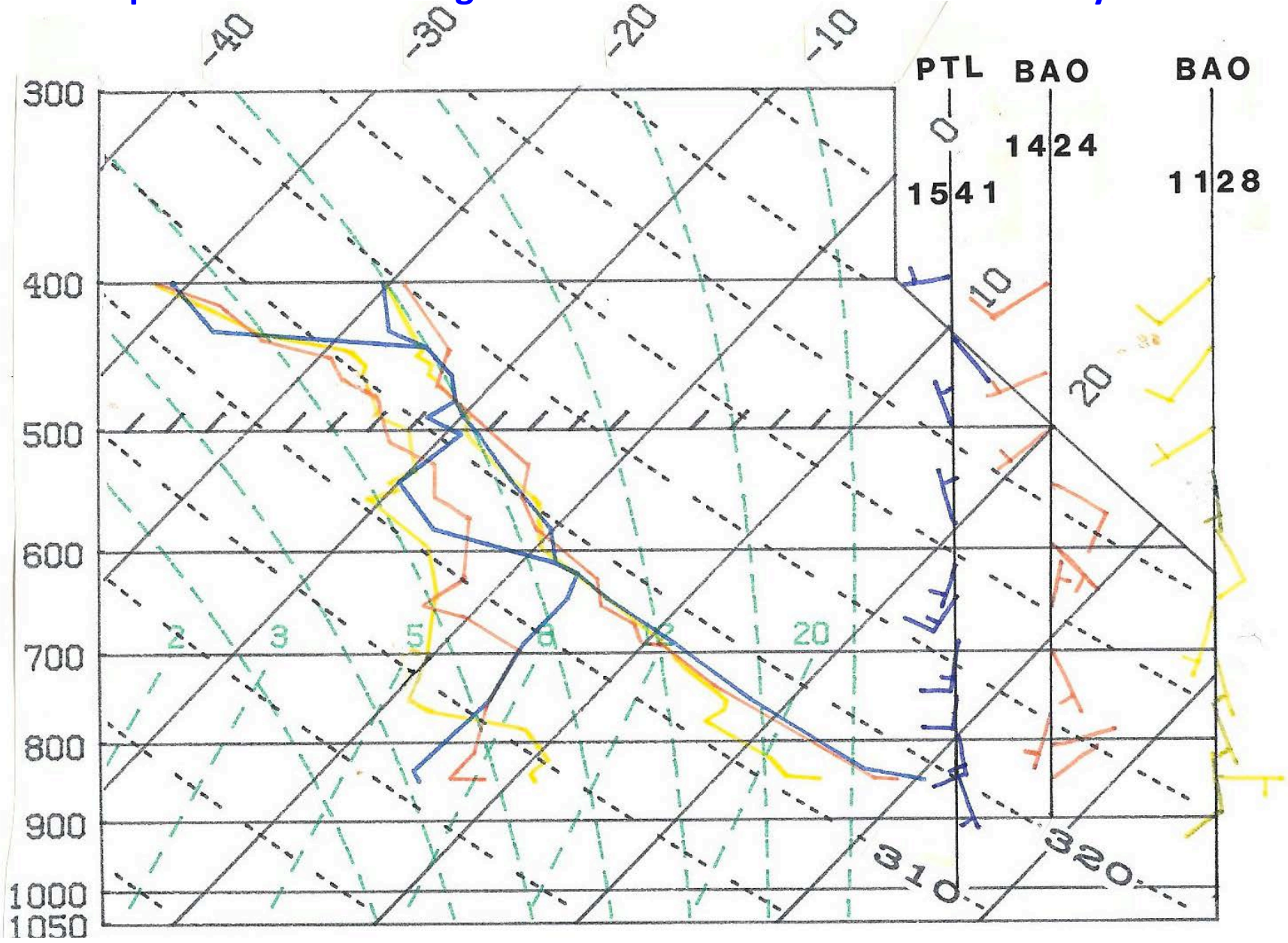


The then-experimental "PROFS Mesonet' 2115z (1515 MDT) on 26 July 1985

Tornado occurs at the arrow from 1535 to 1553 MDT and crossed I-25.

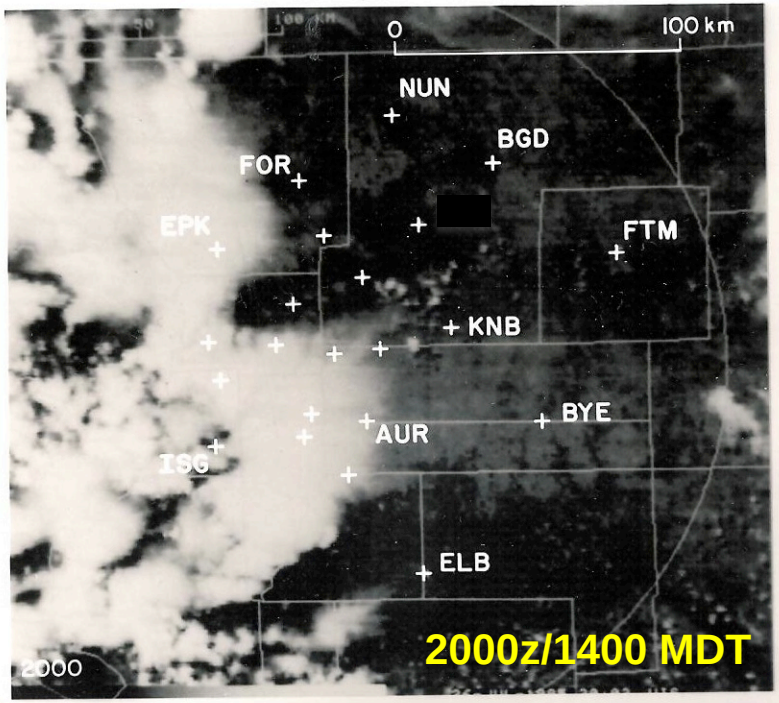


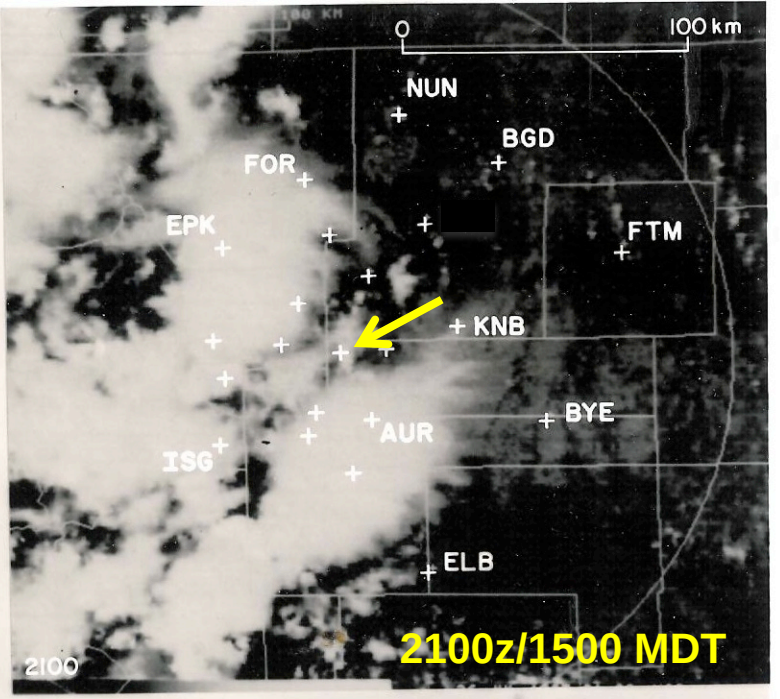
Series of experimental soundings near the DCVZ boundaries on 26 July 1985

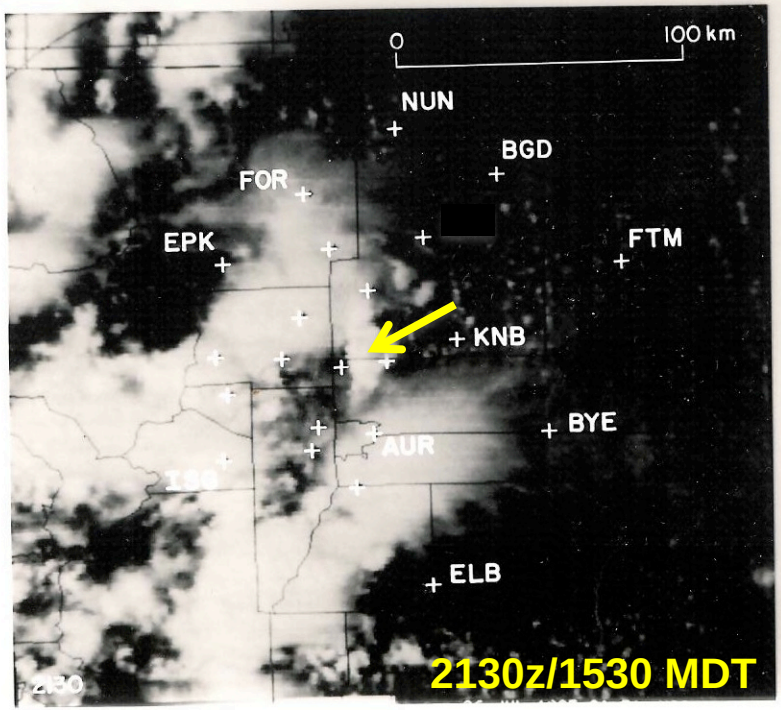


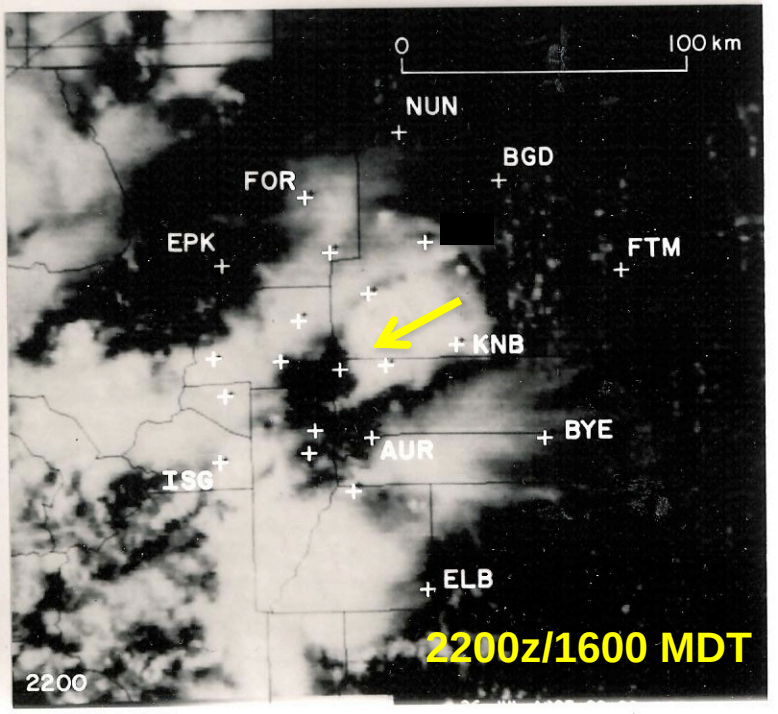
Not only did the boundaries provide the low-level circulation, they also modified the local environment. There was no other severe weather reported on this day.

The grid is slightly off, but this series of visible images shows how the tornadic storm (yellow arrow) ended up forming along the DCVZ in an area that remained in sunshine and where the outflows hit it.







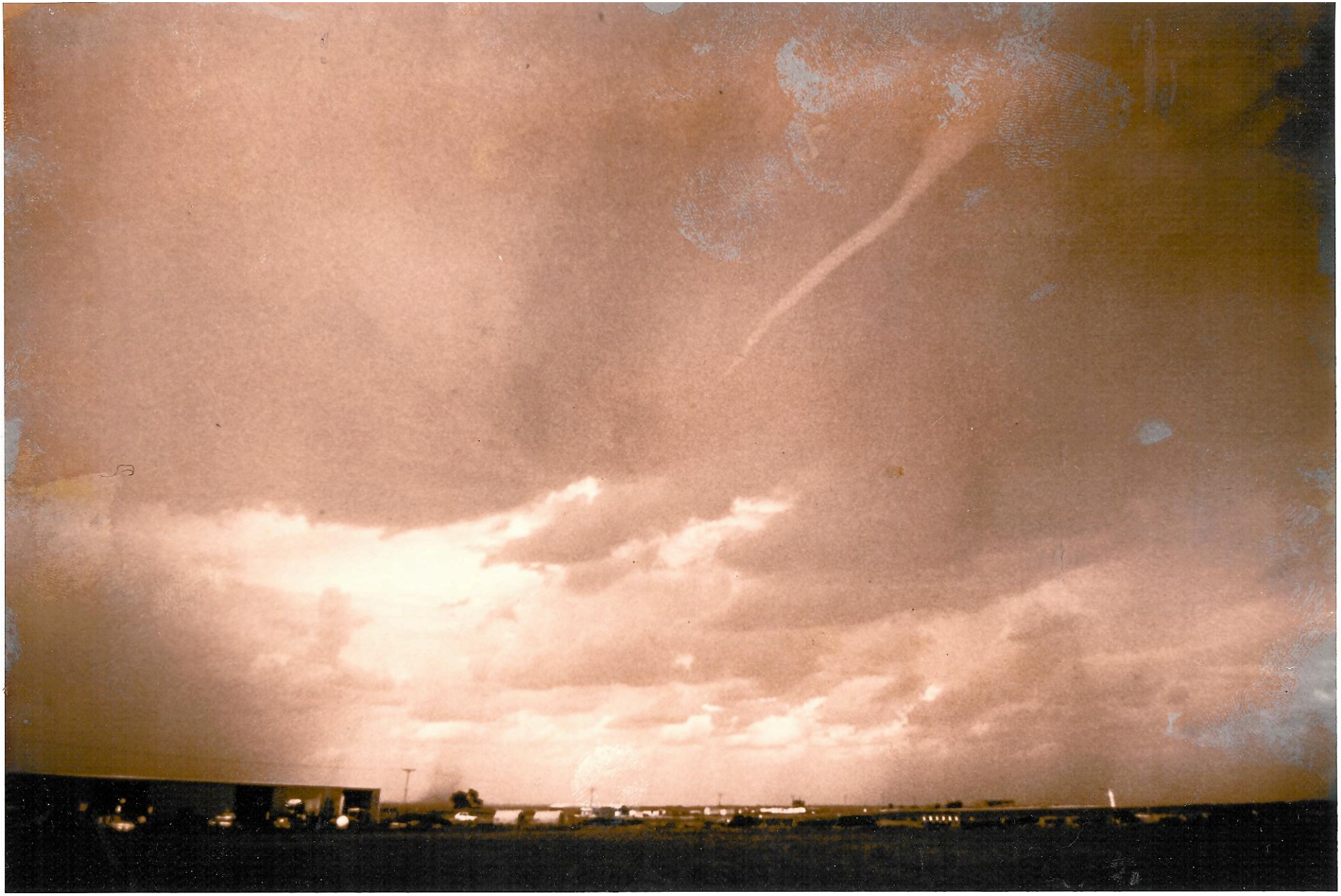


1945z (1345 MDT)

2045z (1445 MDT)

2129z (1529 MDT)

Pictures looking east from Boulder of the initial clouds along the DCVZ and then the explosive development following collision with the weak outflow boundaries.



TODAY

27 July 85

OBITUARIES 2
NATION 3
CLASSIFIED 5-22

D

Tornado flips truck on I-25

Staff and wire reports

Four people in a Ryder rental truck must have felt like Dorothy in "The Wizard of Oz" Friday when their truck was flipped into the air by a tornado that touched down on Interstate 25 near the Lafayette exit.

The truck landed on its left side and slid into a Dodge Colt carrying three passengers. The car's windows had imploded from pressure just before the truck slid into it.

All passengers of both vehicles, including an 11-month-old baby, were wearing seat belts or child restraints. Injuries were limited to minor cuts from flying glass.

The tornado, spawned by a severe thunderstorm, churned for 18 minutes across southeastern Weld County on Friday afternoon. Beside the truck-car accident, damage also was reported to a $500 storage shed which was shoved off its foundation.

The twister touched down at 3:35 p.m. in extreme southwest Weld County and held its course until 3:53 p.m., blowing up a dust cloud that brought traffic on Interstate 25 to a halt.

A funnel cloud also was spotted between Brighton and Commerce City, to the south, but it was not reported on the ground. The National Weather Service said there were reports of a second tornado on the ground while the first was weaving between Erie, Dacono, Fort Lupton and Brighton, but that the second tornado could not be confirmed.

A paramedic in the Weld County sheriff's office said the travelers in the damaged truck, whose names were not available, "spotted a dust cloud and decided that it was a tornado about the time one of the signs was ripped up and thrown across the highway. All of a sudden the truck was being blown all over the highway."

Meteorologist Jim Kaplan from the National Weather Service said the tornado activity came from a "very strong thunderstorm."

He said the tornado was confirmed by a team of researchers from a Boulder program called Prototype Regional and Forecast System.

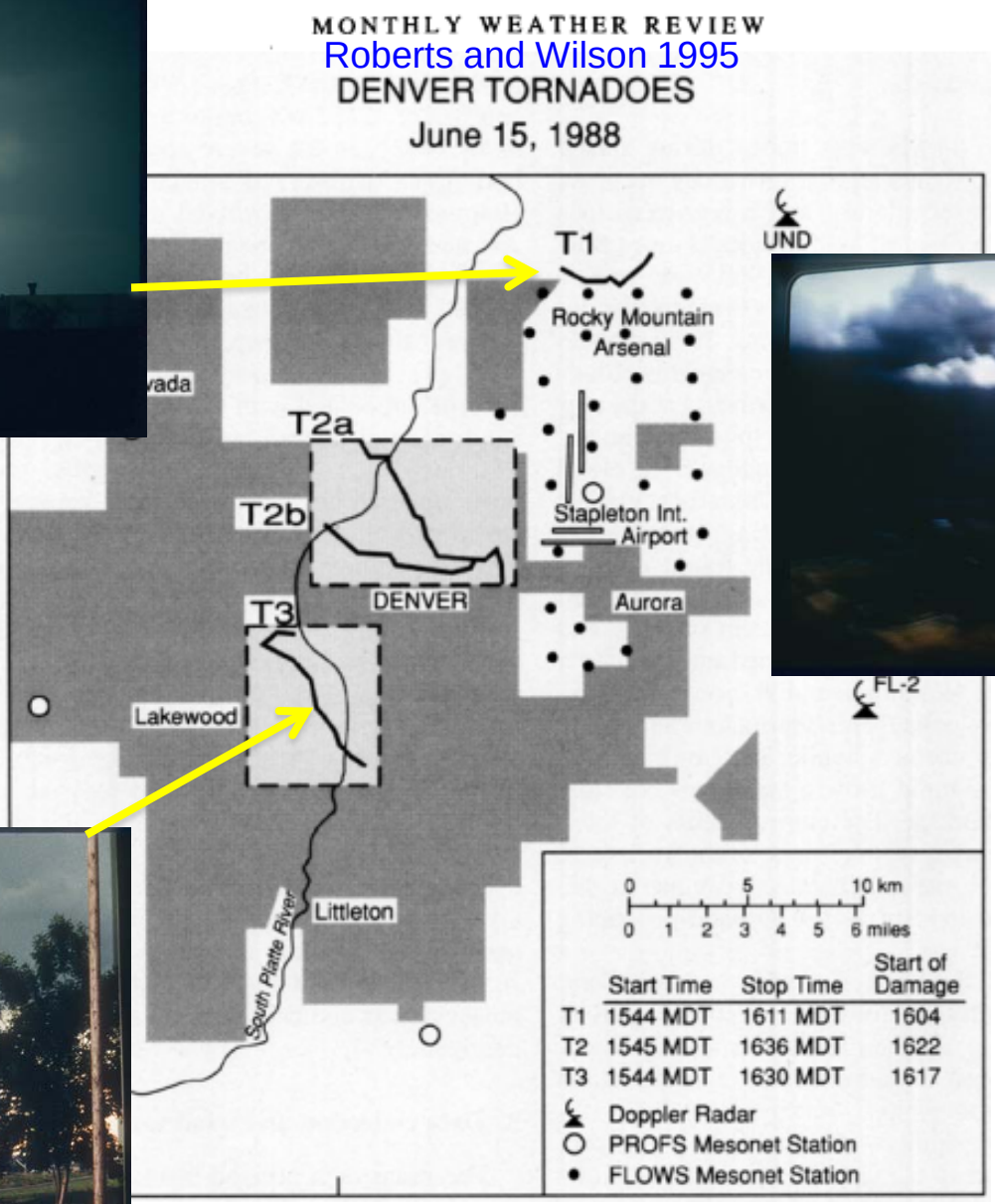
From the Boulder Daily Camera on 27 July 1985

Example 3: The Big One – 4 Denver area significant non-supercell tornadoes within half an hour on 15 June 1988

- Another Denver tornado outbreak, but shifted to the east of the 3 June 1981 tornadoes
- Some vertical wind shear, unstable environment
- Another nice example of how it often takes an interaction(s) to produce the spin-ups
  - In this case two outflows that intersect the DCVZ in just the right way
- One tornado went over the old Stapleton Airport

~2208z (1608 MDT) F1

4th tornado is near Brighton

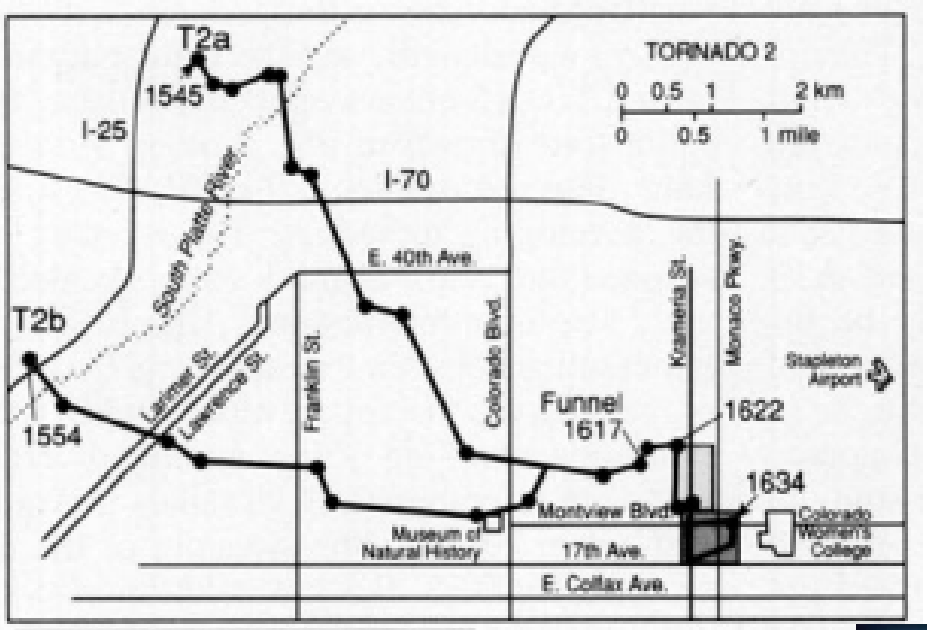


~2225z (1625 MDT) F1

~2225z (1625 MDT) up to F3

Note the different appearances of the tornadoes – we found this was related to moisture differences rather than strength.

From Roberts and Wilson MWR 1995



I believe the tower was evacuated for this tornado.

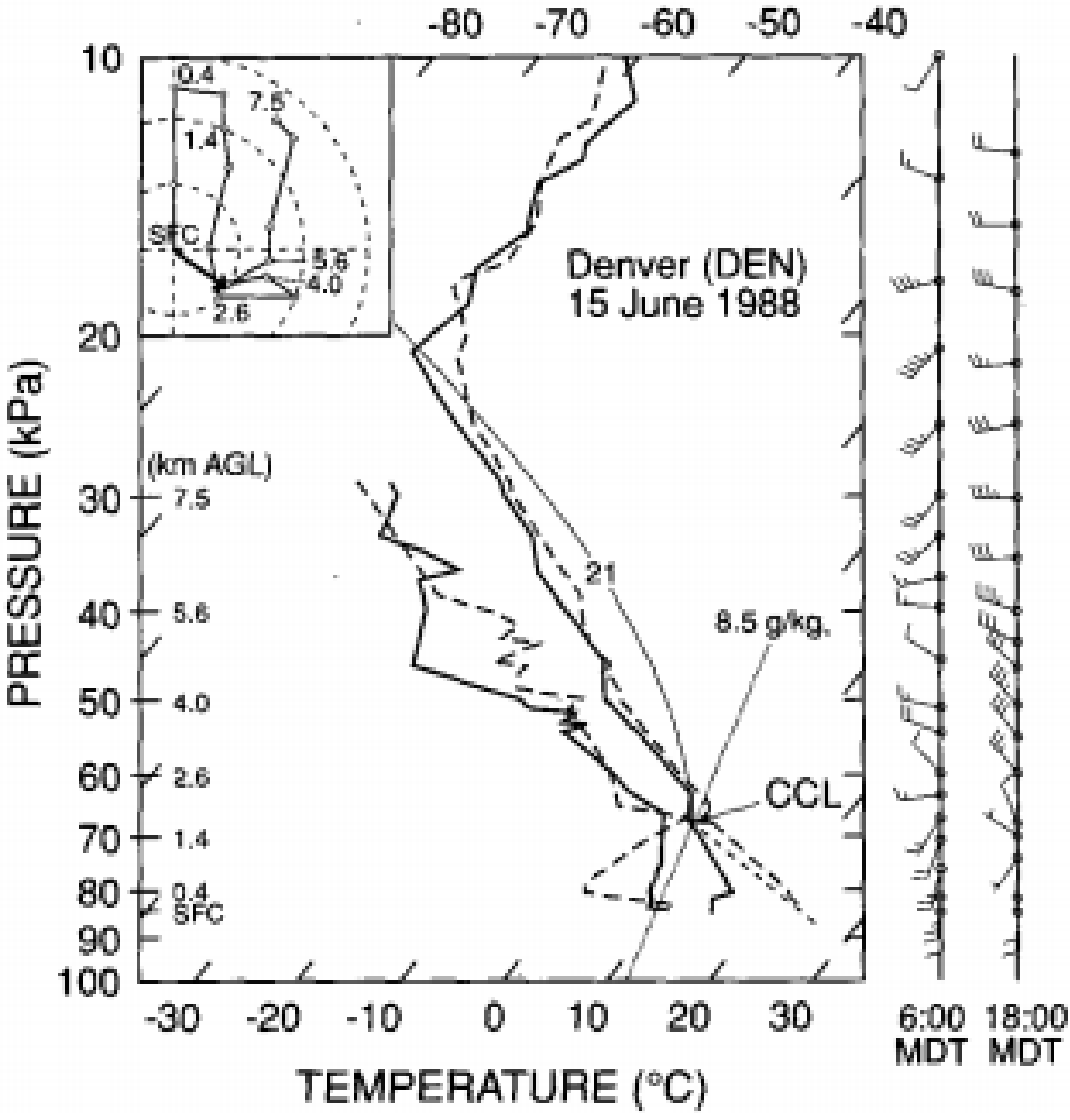
X approximate location of where picture was taken

I took this picture ~2223z (1623 MDT) looking WSW across the old NWS site (radome building is visible). Largest condensation funnel I had seen. Could also see trees/branches being ripped from the ground. Max damage was F2.

This from Rita's paper: what did the planes do?

Denver Soundings from Roberts and Wilson MWR paper.

There is some decent vertical wind shear on this day and some storms to the east of Denver produced severe sized hail.



Summary of the 2 outflow boundaries hitting the DCVZ and producing the tornadoes

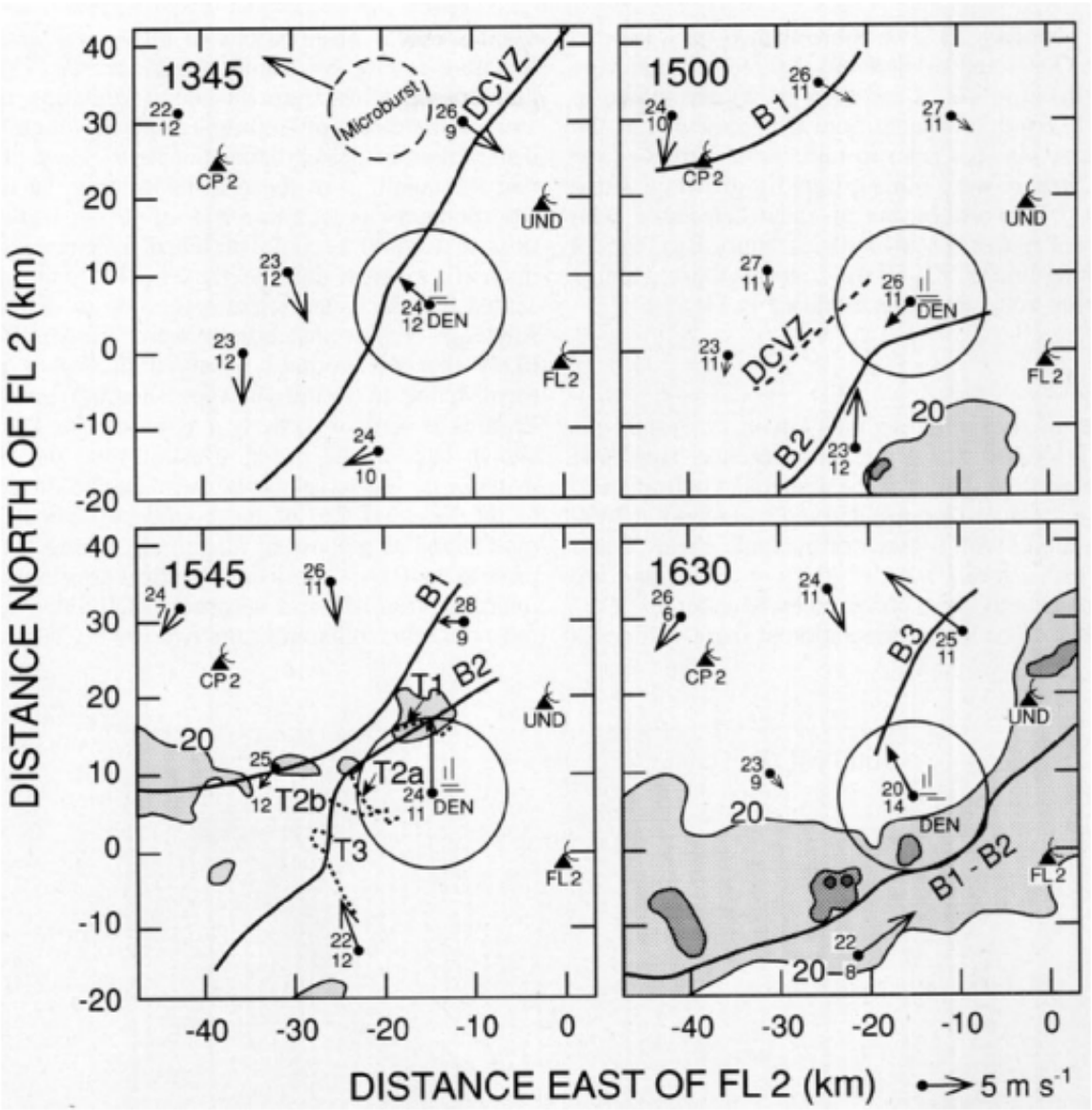
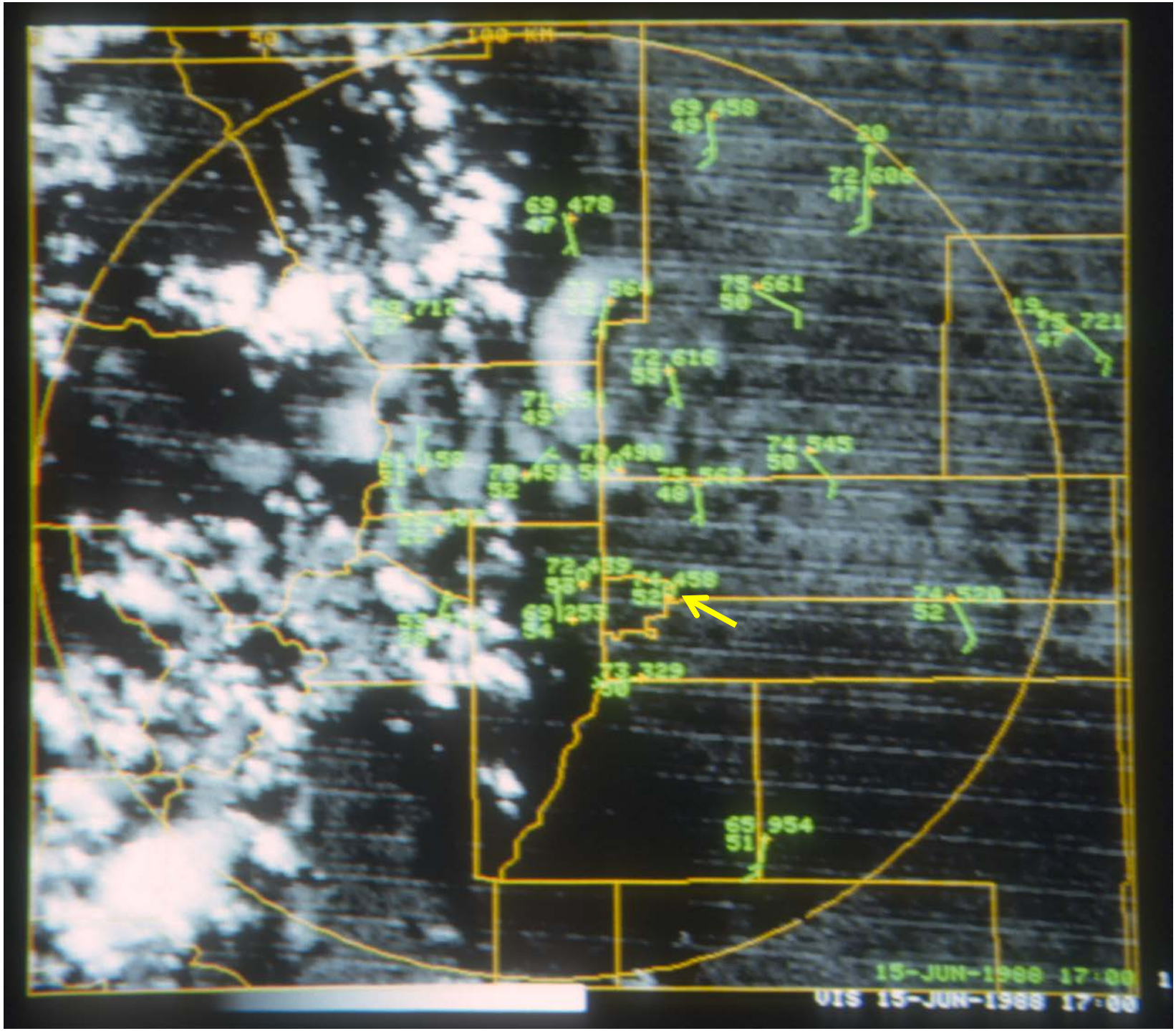


FIG. 5. Near-surface locations of convergence lines (solid curves) detected by Doppler radar and surface winds (vectors) recorded by the PROFS mesonetwork near Denver, Colorado, at four time periods. Mesonet temperature and dewpoint (°C) values are also shown. The 20-km circle centered on DEN and STP is provided as a reference. The NCAR CP-2 radar was located 50 km to the northwest of FL-2 and collected surveillance scans. Shaded areas are 20-dBZ echoes at approximately 6 km AGL: (a) 1345, (b) 1500, and (c) 1545. Dark shaded areas are echoes of at least 50 dBZ, at 6 km AGL. Dotted lines denote the tracks of rotations T1, T2a, T2b, and T3 at approximately 5-min intervals: (d) 1630 MDT.

1700z (1100 MDT) on 15 June 1988

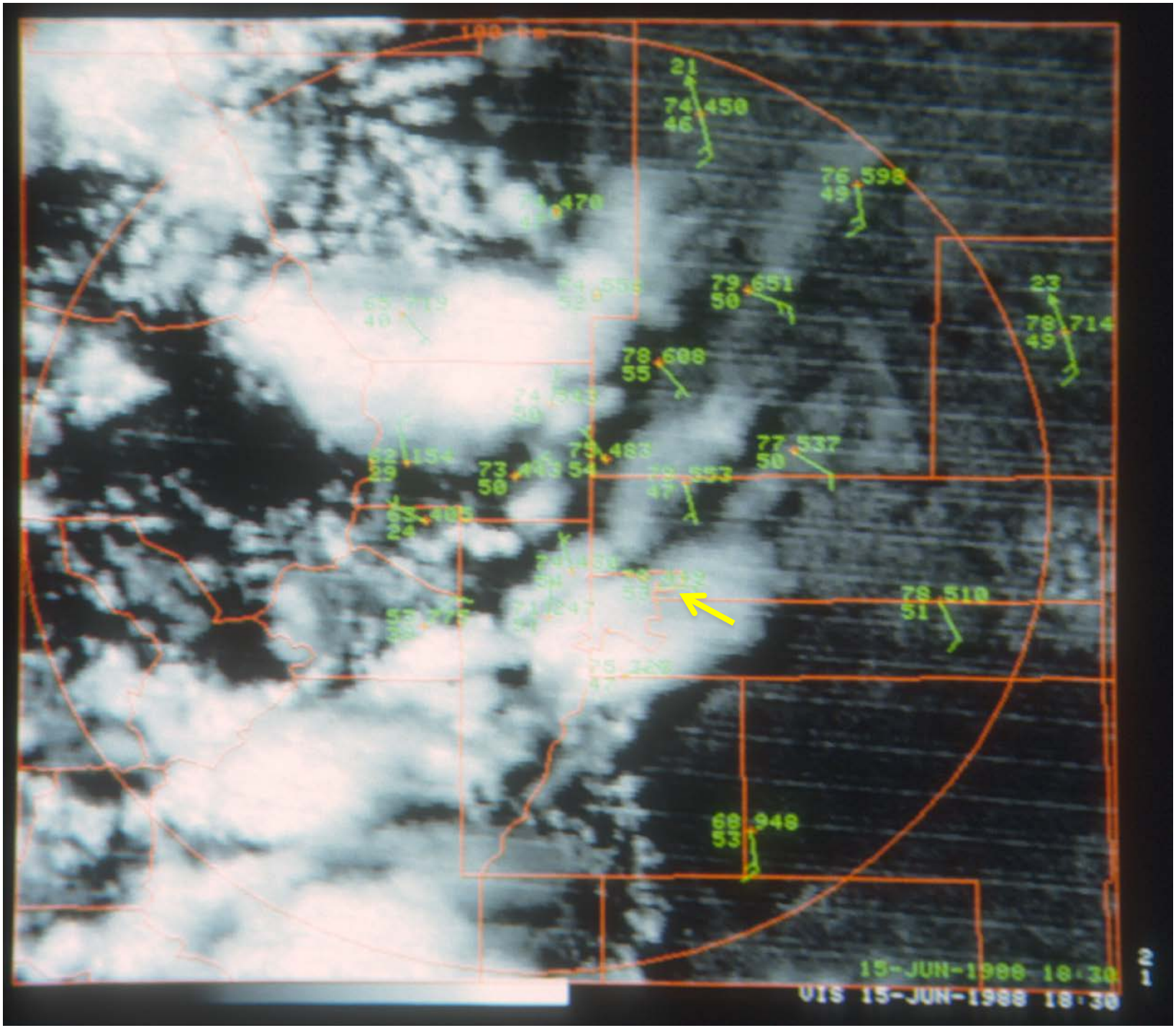
Fairly typical with dew points near 50 to the lower 50s. S to SE flow on the plains but fairly disorganized flow near and west of the airport.



1830z (1230 MDT) on 15 June 1988

The DCVZ is not particularly strong but is about over the airport.

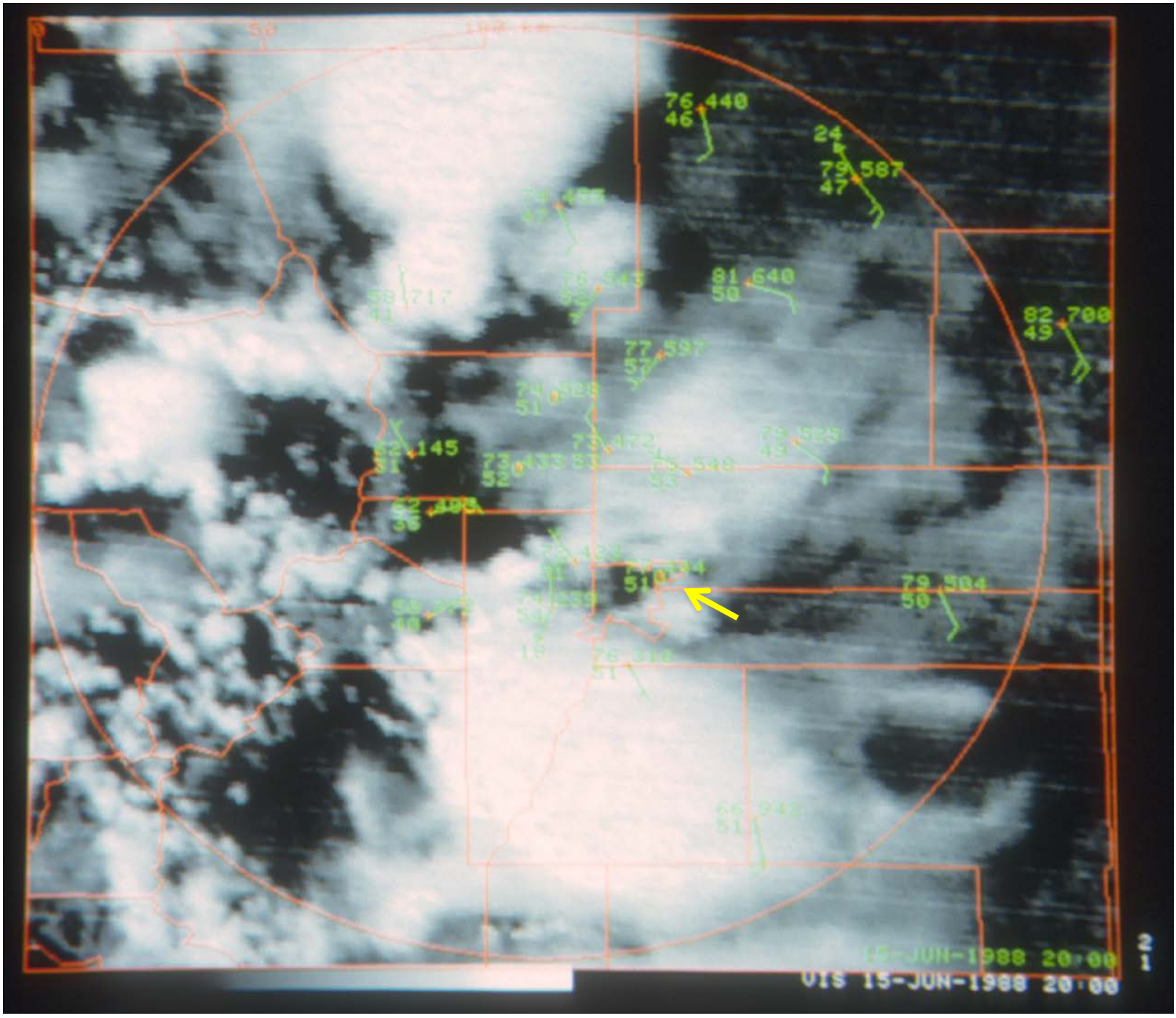
Early storms have developed to the south over the Palmer Divide and in the foothills and mountains nw of Boulder.



2000z (1400 MDT) on 15 June 1988

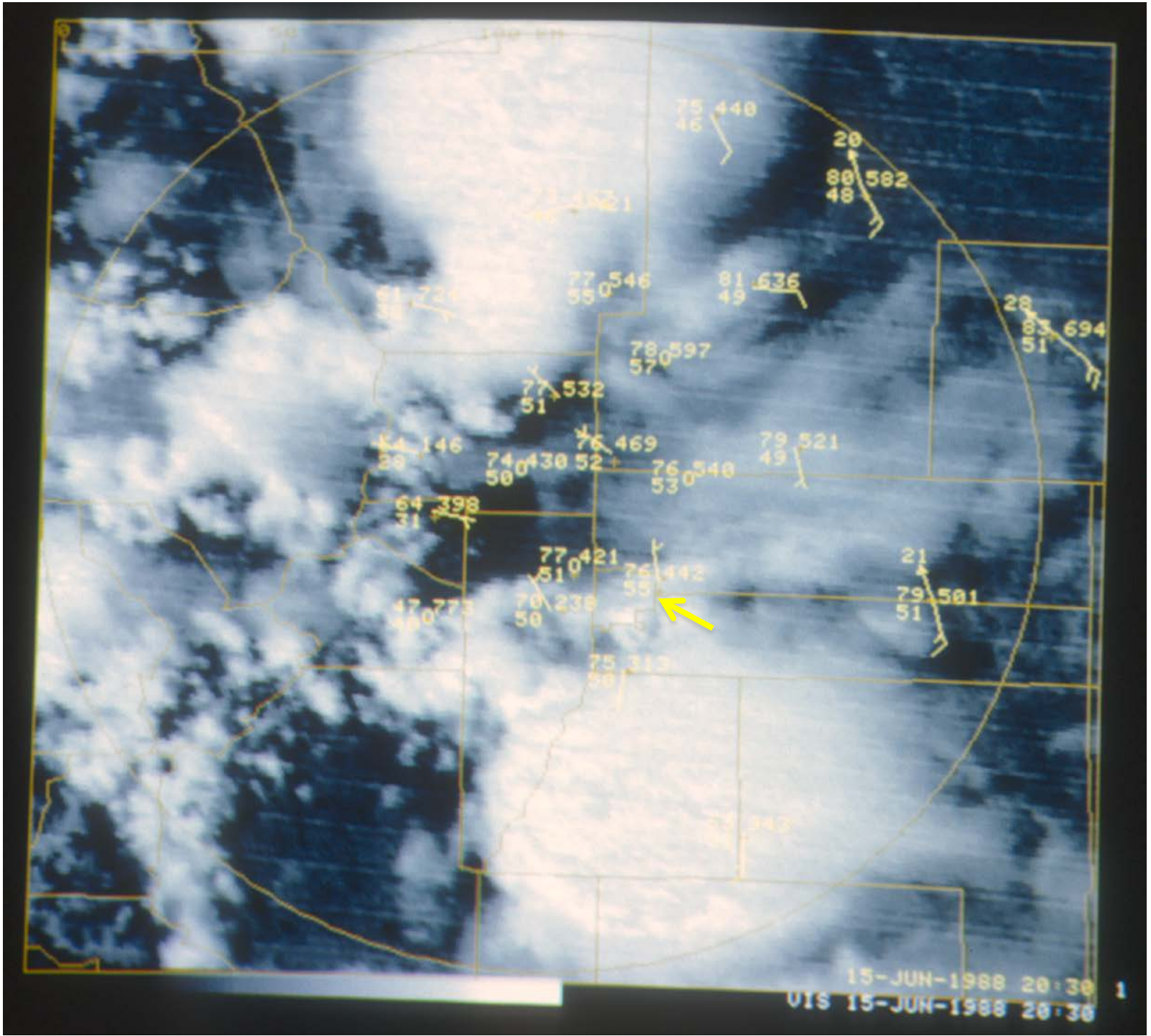
The wind at Stapleton Airport is calm with temp=77 and dew point 51.

Storms continue to move off the foothills with some outflow from the NW. Pretty big storm to the south.



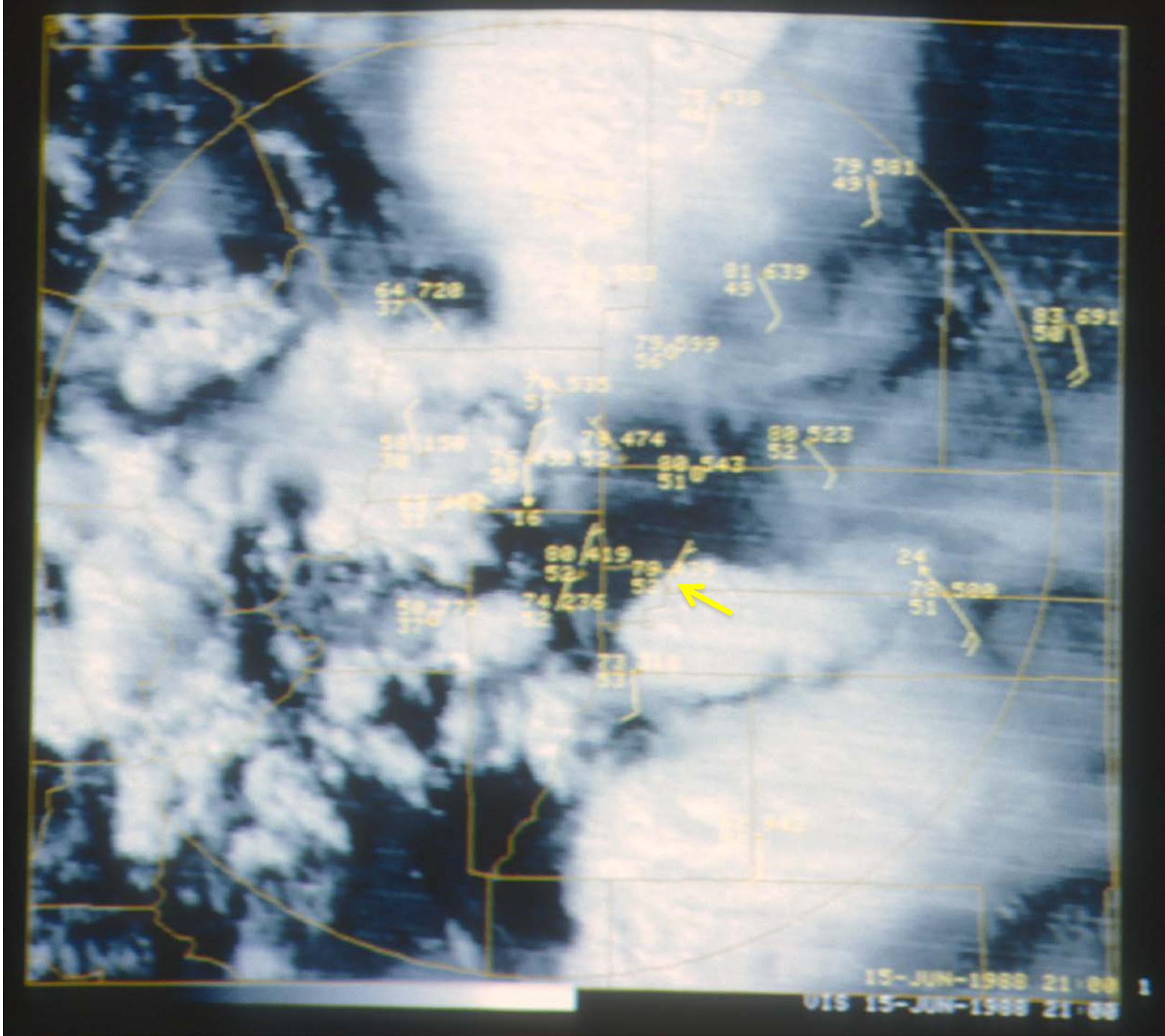
2030z (1430 MDT) on 15 June 1988

The DCVZ is still not that strong but is right over the airport.



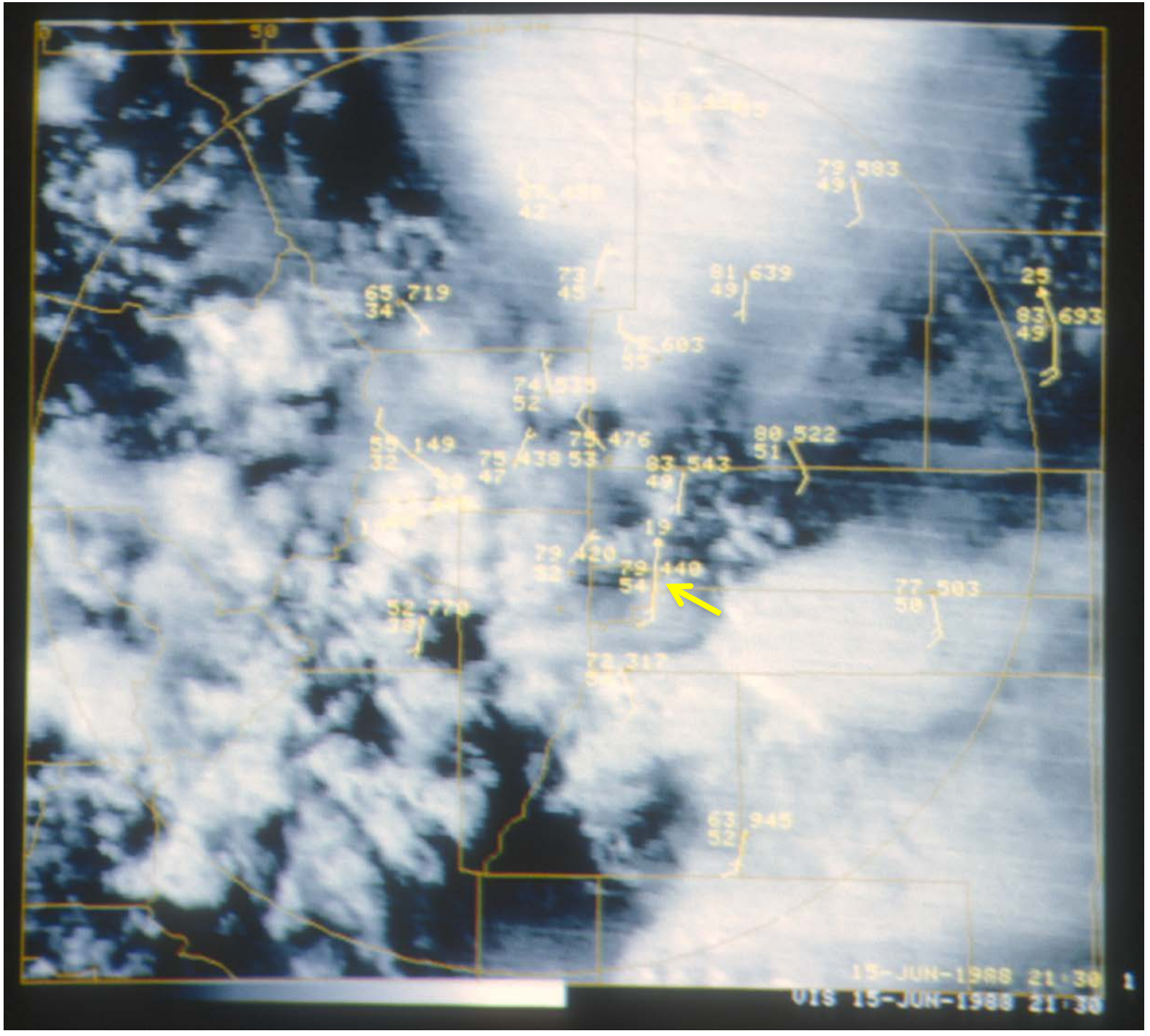
2100z (1500 MDT) on 15 June 1988

The storm well to the se of the airport produces an outflow that moves to the nw and appears to produce a storm on the DCVZ south of the airport. But this storm moves away, develops mid level rotation and severe hail but no tornadoes (and sucks chasers to the east!).



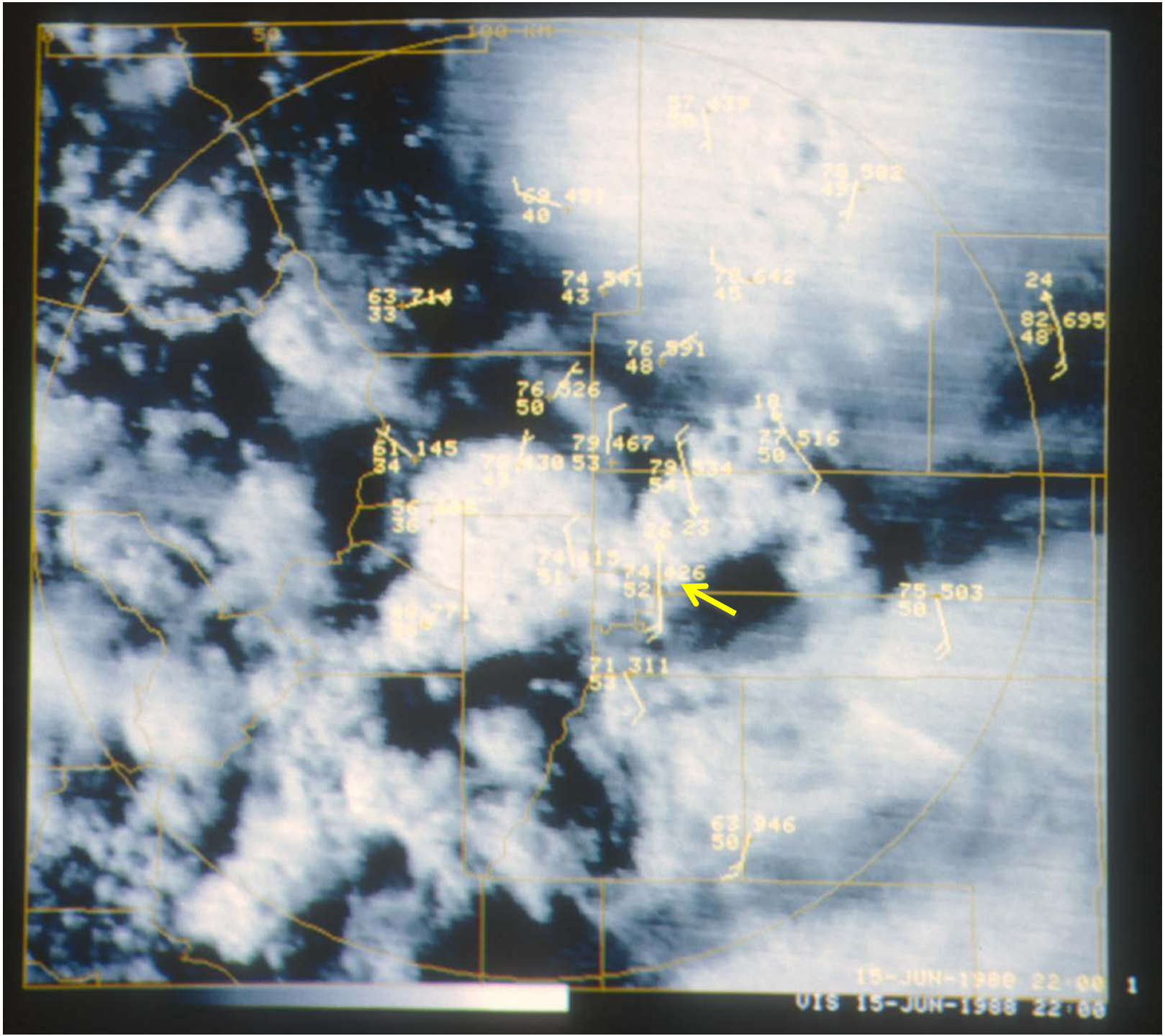
2130z (1530 MDT) on 15 June 1988

But that new storm sends another outflow to the NW towards the DCVZ. Meanwhile the weak convection over Boulder County sends an outflow to the SE towards the airport.



2200z (1600 MDT) on 15 June 1988

And then they intersect.



Detailed look at the flow near the DCVZ after it was intersected by the 2 outflow boundaries at 1600 MDT (dual-Doppler analysis from Roberts & Wilson, MWR)

It is believed that the way the two gust fronts intersected the DCVZ at an angle, instead of head on, produced an unusually large number of small-scale circulations, some of which grew into the 4 tornadoes.

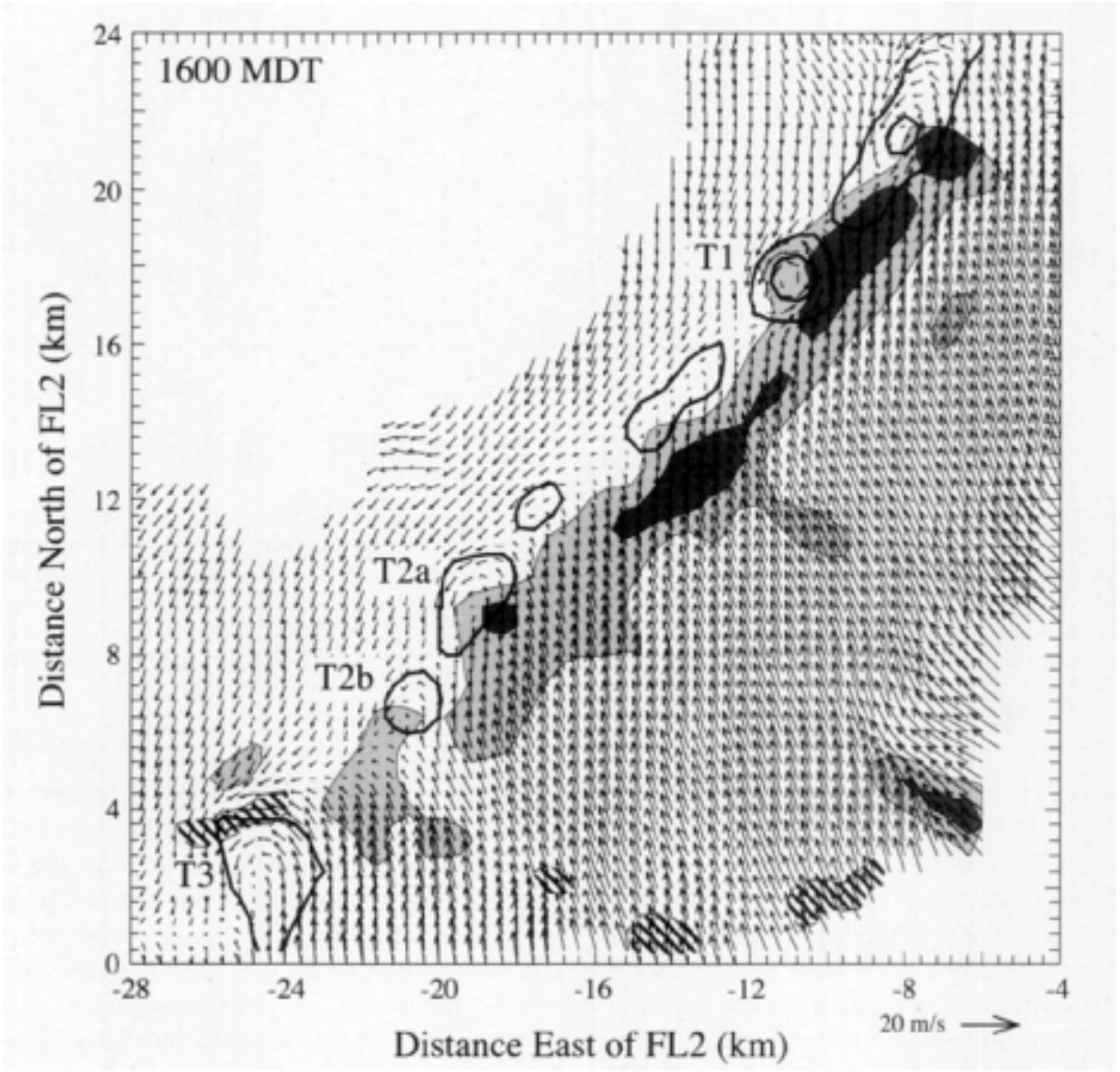
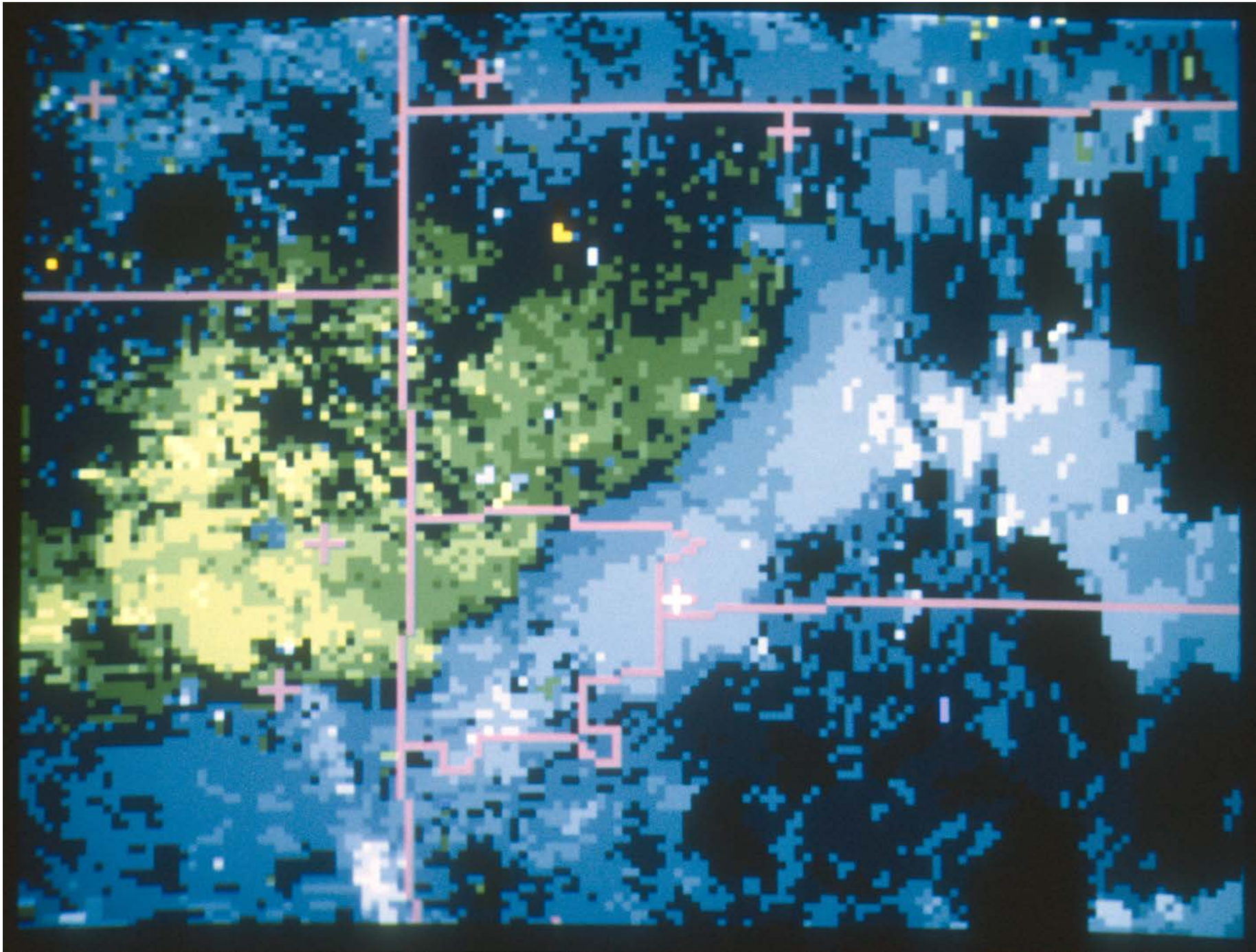


FIG. 6. Dual-Doppler-derived horizontal, storm-relative winds (vectors), and vertical vorticity (contours are 5×10^{-3} and 15×10^{-3} s^{-1}) at 1600 MDT and a height of 0.2 km. The vertical velocity field at 2.2 km is overlaid. Upward (downward) vertical velocity regions are shaded (hatched) in increments of 4 m s^{-1}. The location of circulations T1, T2a, T2b, and T3 are shown. The scale vector is in the lower right-hand corner.

Doppler velocity (blue toward) at 2201z/1601 MDT



FRIDAY

'Bull Durham'
Costner and Sarandon sizzle
FRIDAY MAGAZINE

Detroit leads series 3-2	PAGE 1B
U.S. drought worst in 50 years	PAGE 3A
Senate passes welfare overhaul	PAGE 4A

Boulder County's Complete Newspaper
98th Year No. 94

Daily Camera

June 17, 1988
Boulder, Colorado
25 Cents

County extends model midwife program to Boulder

Childbirth service available to low-income women

By SHARON GILLEN
Camera Staff Writer

'Little' twister damage may top $10 million

Colo. tornadoes less intense than plains states usually get

Associated Press

NORTH, SOUTH WINDS MEET: This NOAA map shows the dominant southerly winds meeting the northerly outflows from the foothills along a broken line east of Denver. Wednesday's storm — which spawned several tornadoes — followed this pattern. But the line of convergence was further west, possibly because of stronger-than-usual downdrafts.

Boulder scientists probing Colorado's 'tornado alley'

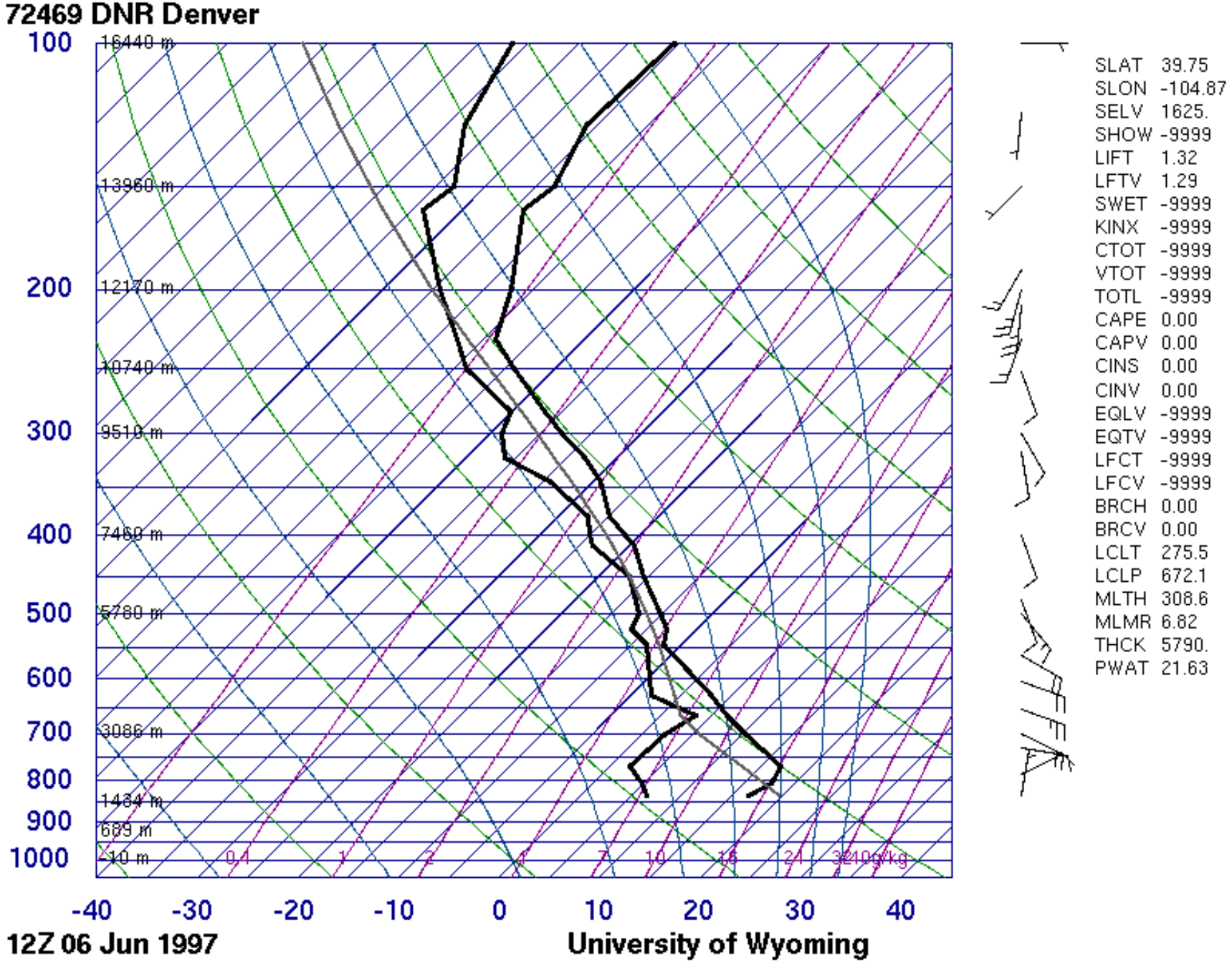
By BILL SCANLON
Camera Staff Writer

Chances slim of big tornado hitting Boulder

Example 4: Speaking of changing appearances – the Boulder tornado of 6 June 1997

- Very moist environment – in fact forecasters worried about flooding rains
- Deeper SE flow – caused the DCVZ to shift from the airport to the WNW with time
- Eventually wound up in eastern Boulder County where it produced a very visible tornado

The Denver sounding on this day (1200z/0600 MDT) has deep ESE flow and this moves the DCVZ westward during the day.

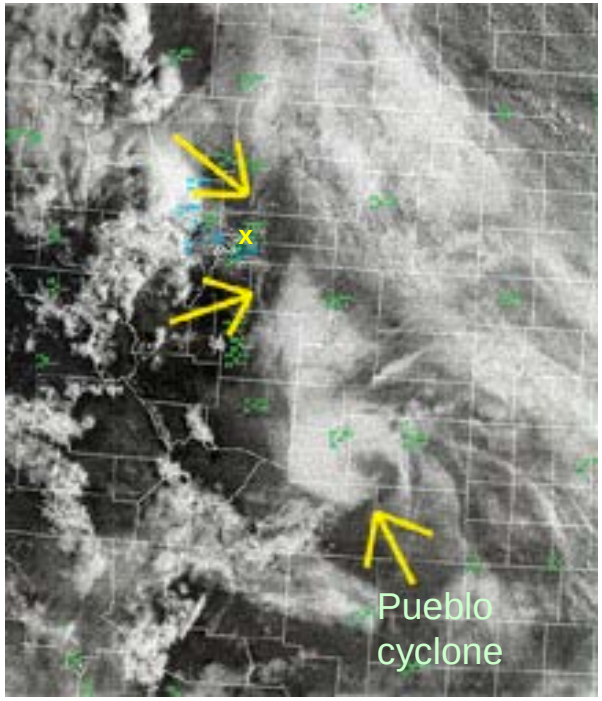


Evolution of the DCVZ on the Boulder tornado day of 6 June 97

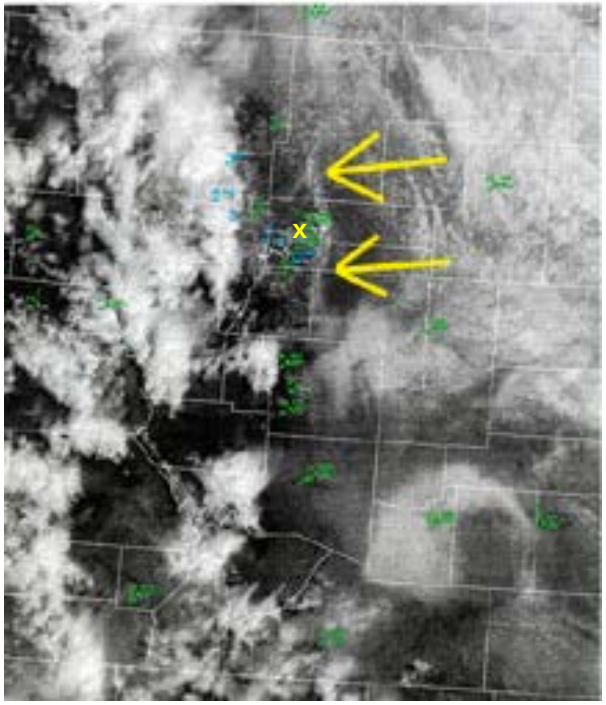
A similar feature to the DCVZ occurs north of the Raton Mesa near Pueblo, and is seen on this day as a cyclonic circulation in the low cloud field.

Other two arrows mark the DCVZ, which slowly moves westward with time as storms develop on it, but no tornado forms until it gets to Boulder County. The tornado develops ~1410 MDT and moves WSW, passing just north of my house then to the west. Why no tornado(es) earlier? Perhaps because the DCVZ was not stationary in this case. Weak outflow from the west may have intersected it in Boulder County.

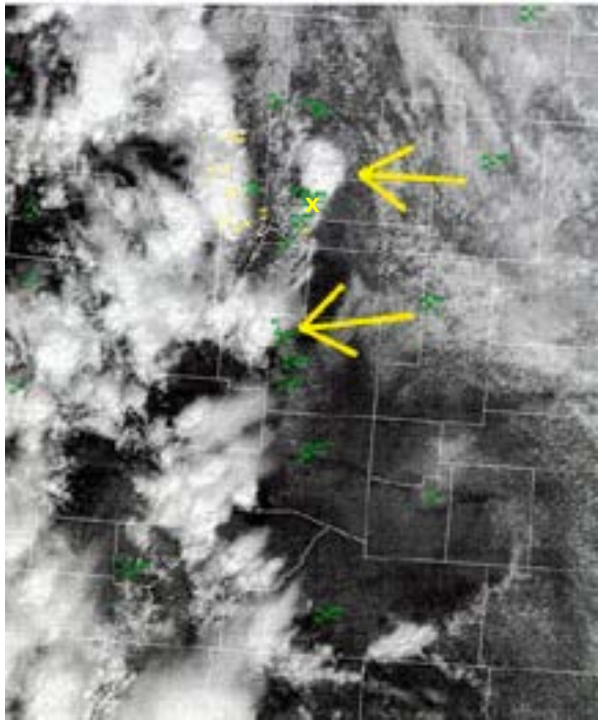
1700z/1100 MDT



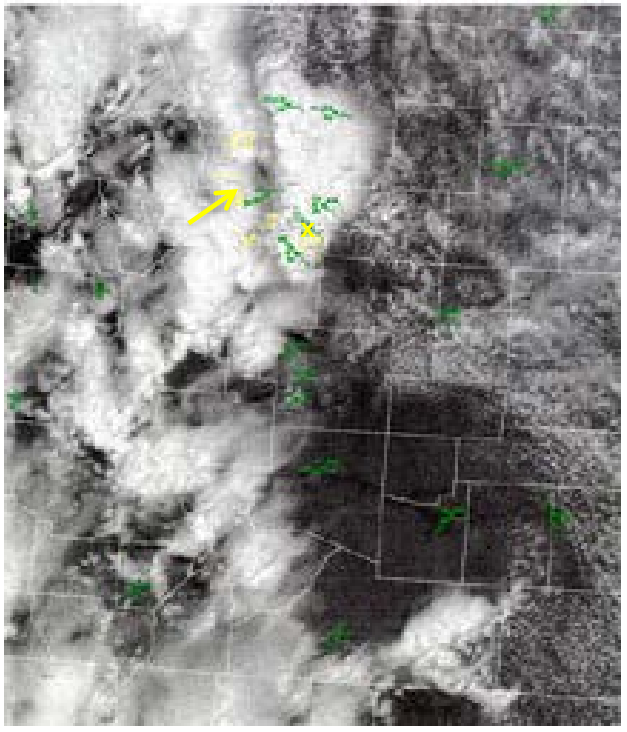
1800z/1200 MDT



1900z/1300 MDT



2000z/1400 MDT



At first this was a typical non-supercell Colorado tornado with a tiny funnel from cloud base and a swirl of dust on the ground. Then it passed over Baseline Reservoir and became a full-fledged Colorado waterspout (this photo ~1415 MDT).

The NWS (then in Denver) actually got the first report of this storm from an observer way to the east in Lockbuie, who estimated it was over Louisville. I called in to NWS to tell them exactly where it was, near my house! After exiting the lake on the SW side the tornado lifted about 1420 MDT.

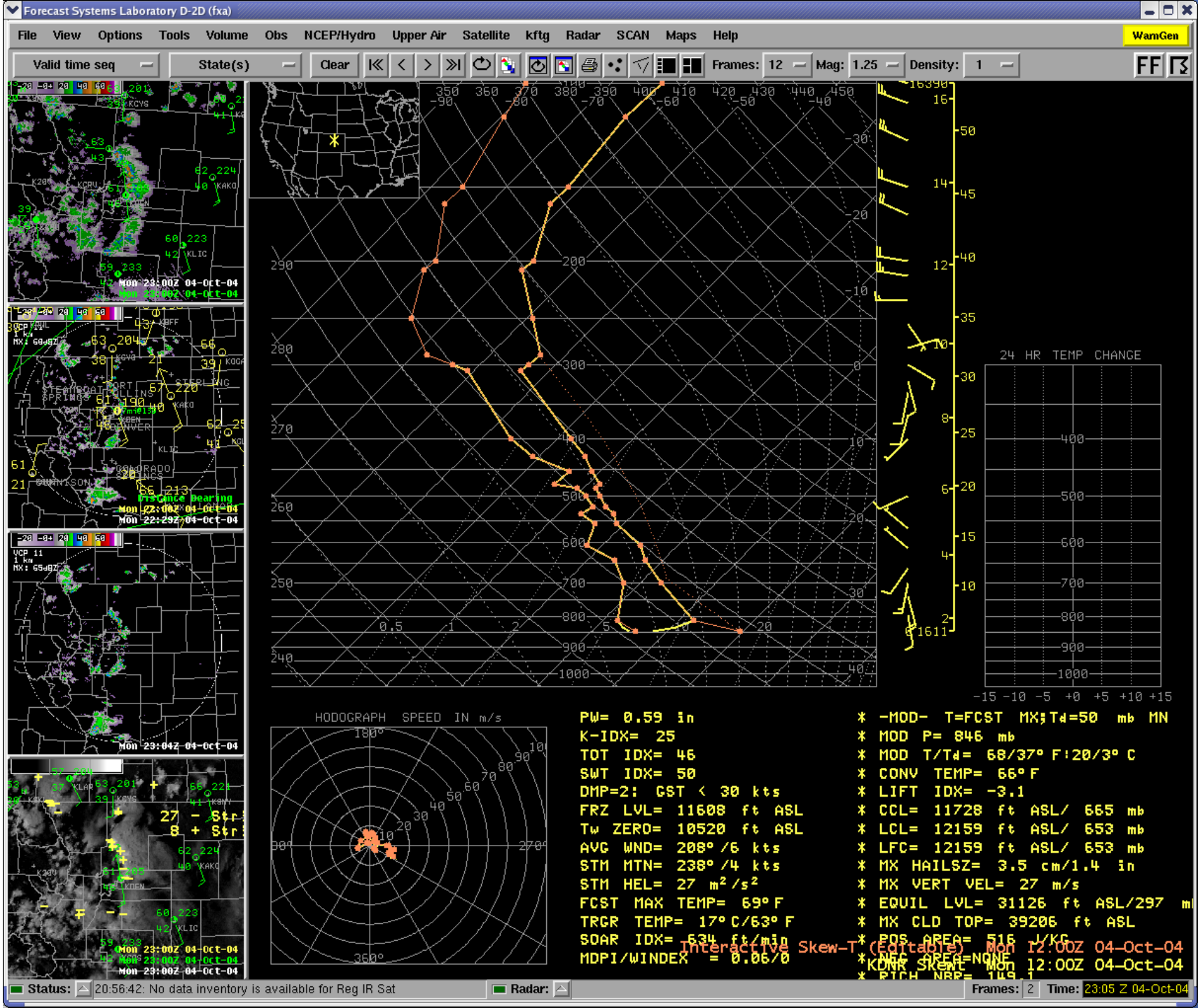
I did a bicycle survey and found a 2x4 in the side of a barn just across from where it entered the lake. The owner said the plank had been in the barn before the tornado. The tornado reportedly turned a car sideways on Baseline Road. Just before it entered the lake it crossed a small field of foot tall grass, and one could clearly see flattened grass but no more than about 20 feet across. Rated as an F1.

Example 5: October tornadofest near DIA. 11 tornadoes reported on 4 October 2004

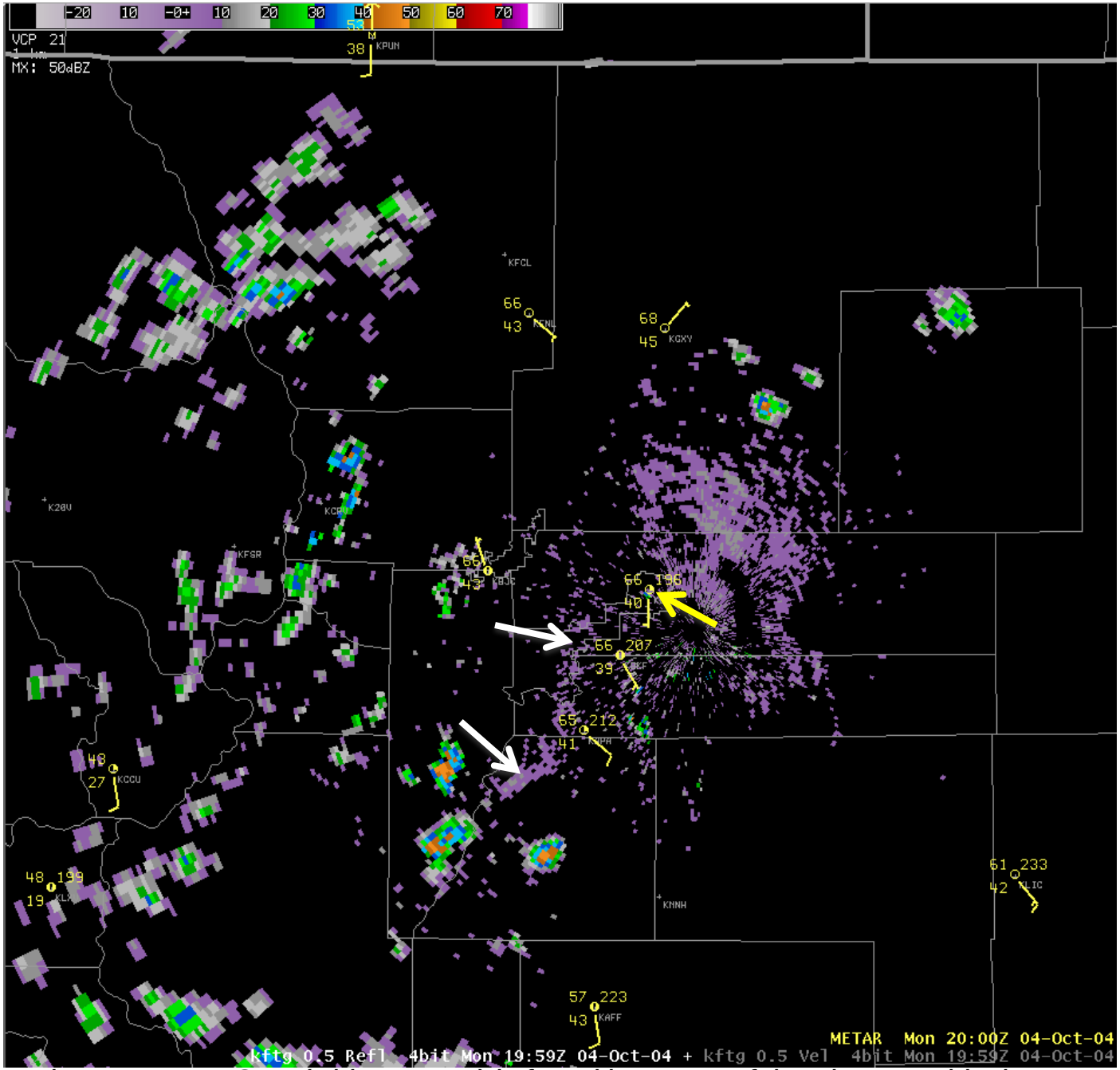
- 11 non-supercell tornadoes developed NW of DIA
- F0 except 4 rated F1
- Occurred within a 44 minute period from 2204-2248z (1604-1648 MDT)
- Tornadoes developed after the DCVZ was intersected by a thunderstorm outflow boundary from the east

12z/4 Oct 2004 Denver Sounding

Weak vertical wind shear but a fairly unstable and moist airmass.

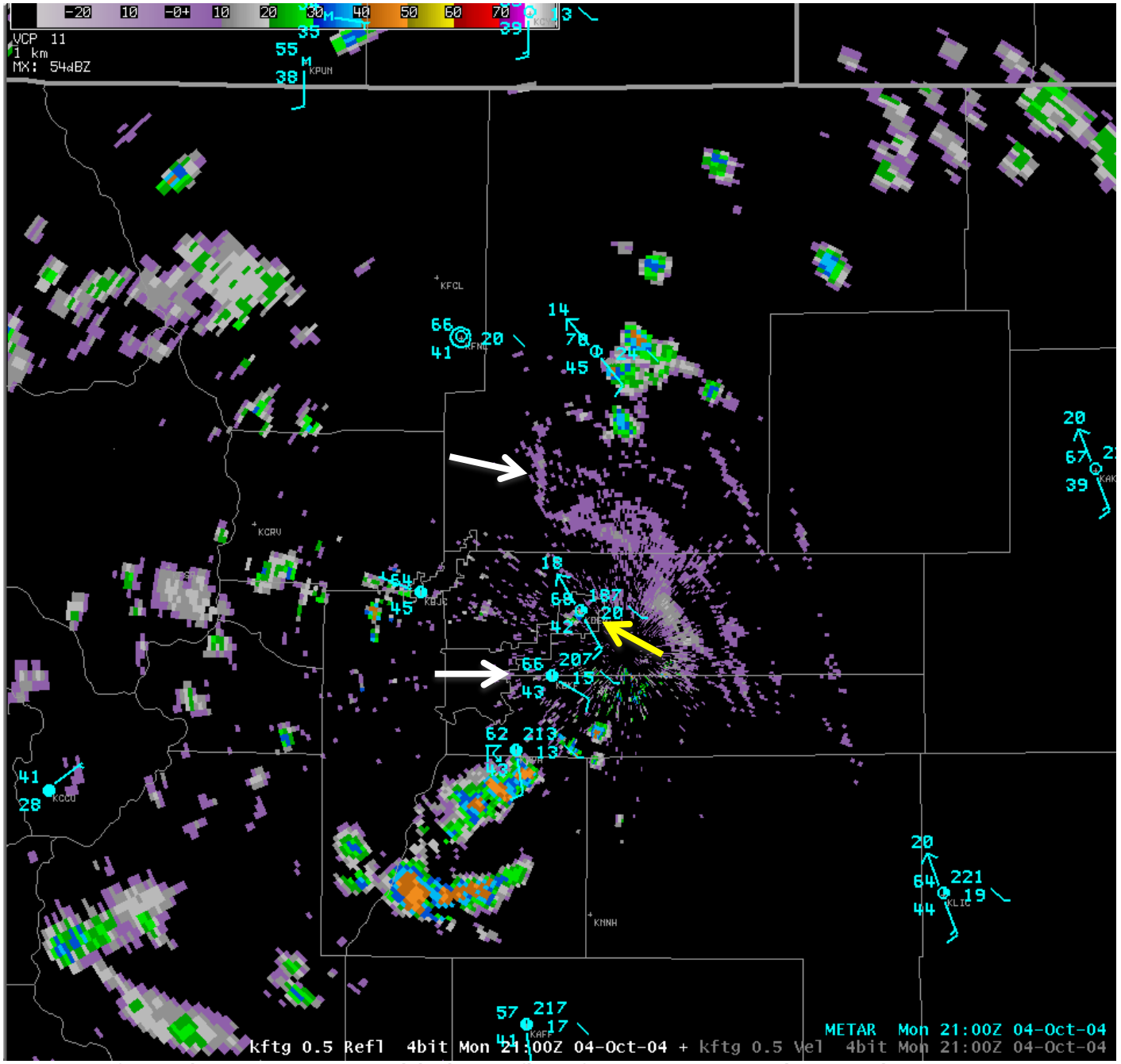


METAR plot with radar reflectivity at 2000z/1400 MDT on 4 Oct 2004



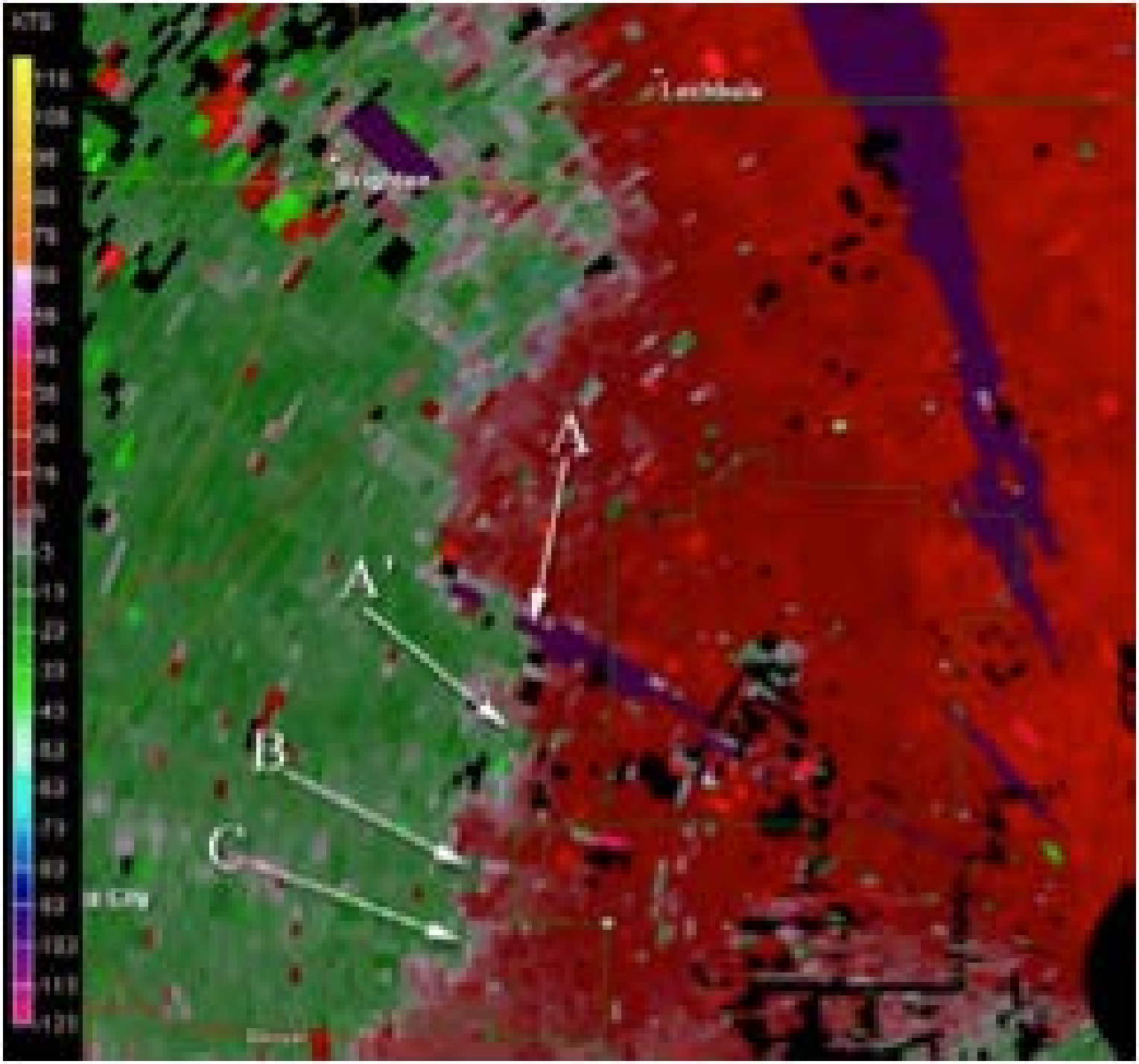
Yellow arrow points to DIA. DCVZ (white arrows) is found just west of the airport at this time.

METAR plot with radar reflectivity at 2100z/1500 MDT on 4 Oct 2004



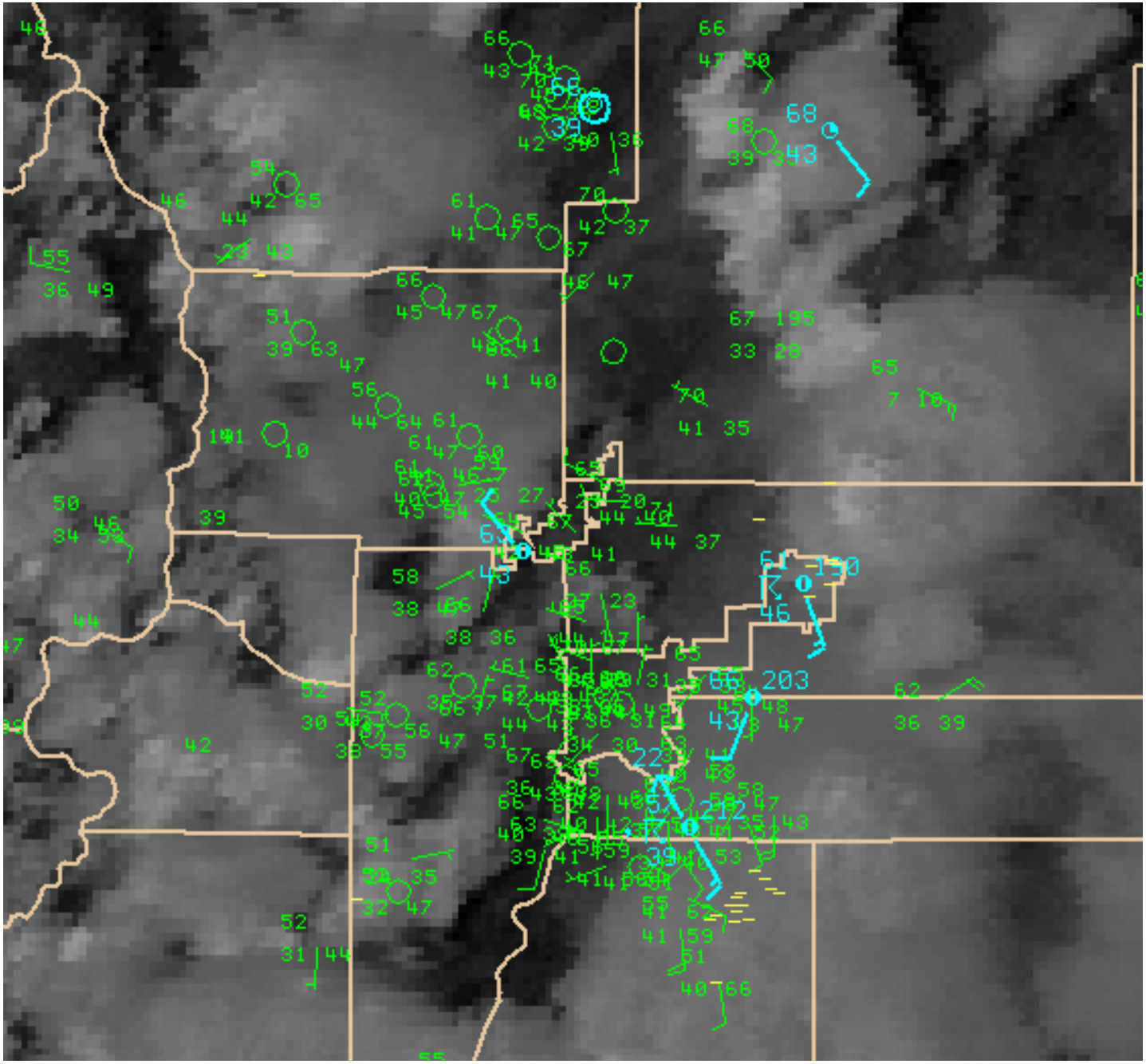
Note the wind increase from the SE at DIA – this is outflow from storms to the south

A close look at the velocity (from the KFTG radar) at 2115z showed 4 small scale circulations present along the DCVZ.



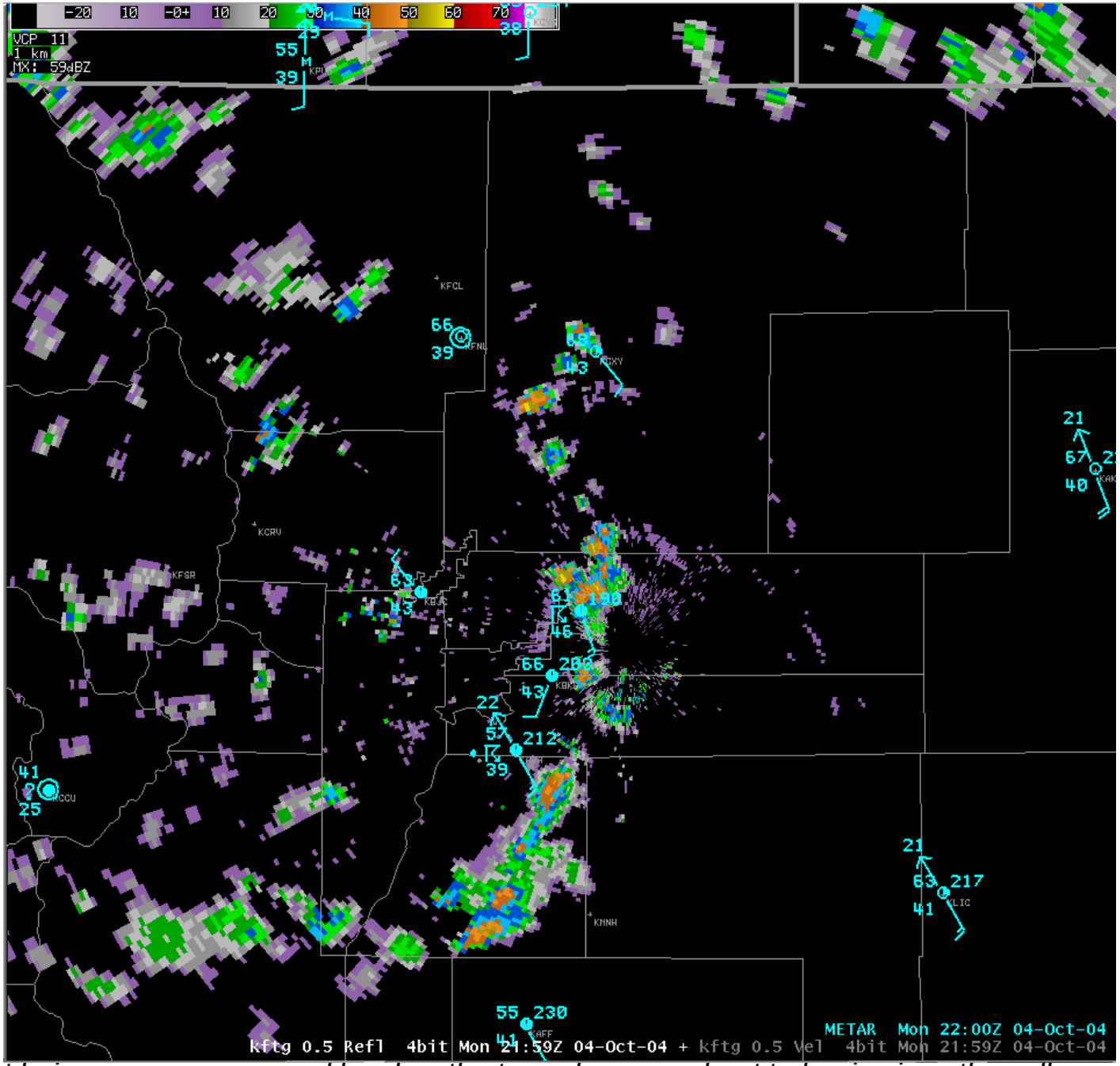
Green is toward, red away.

Visible image with observations at 2200z/1600 MDT on 4 Oct 2004



Just before the tornadoes start. The weak storms to the east sent a surge westward, foothills cells a weak surge to the

METAR plot with radar reflectivity at 2200z/1600 MDT on 4 Oct 2004

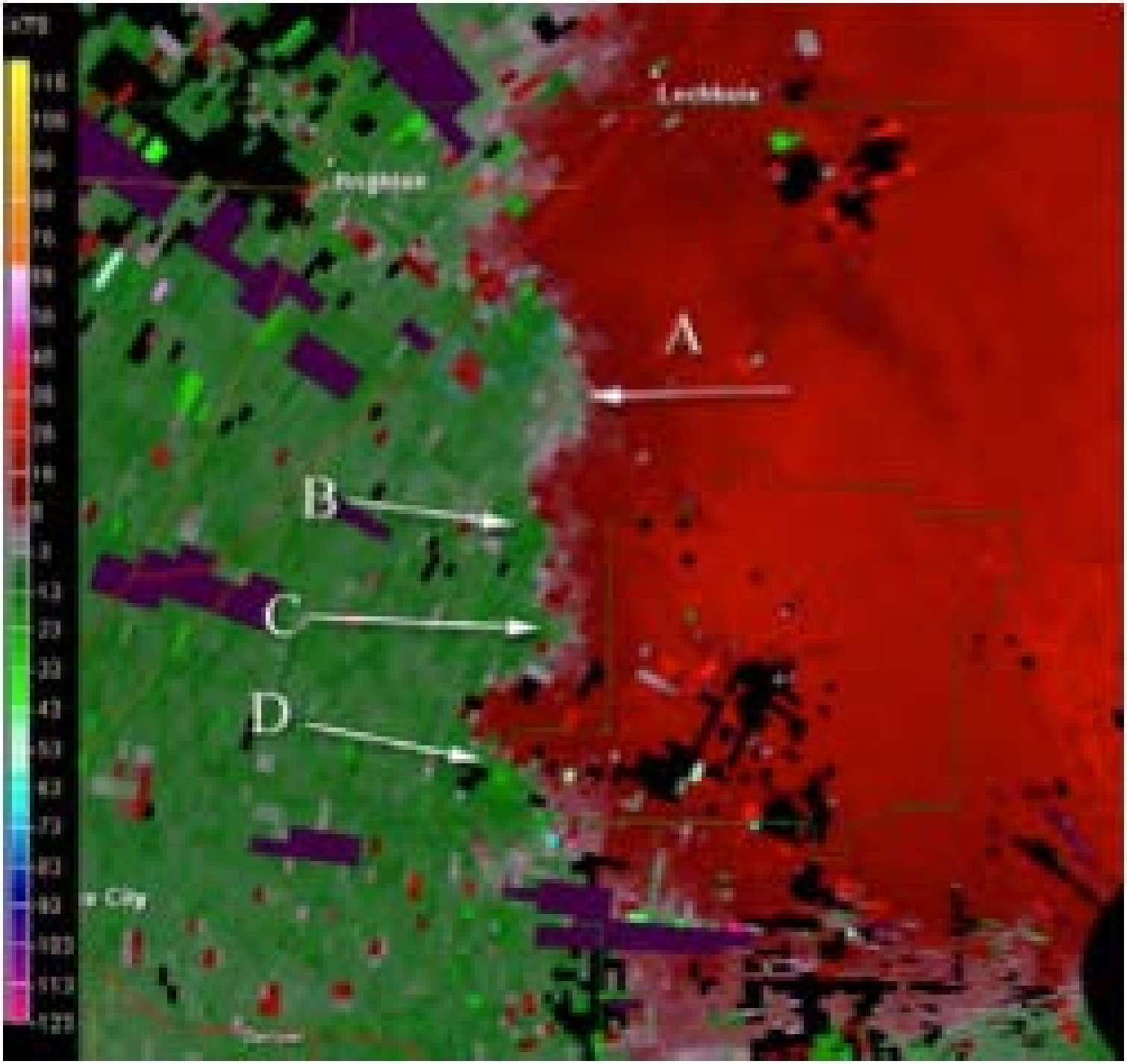


Echoes are just being seen near ground level as the tornadoes are about to begin since the cells are growing still.

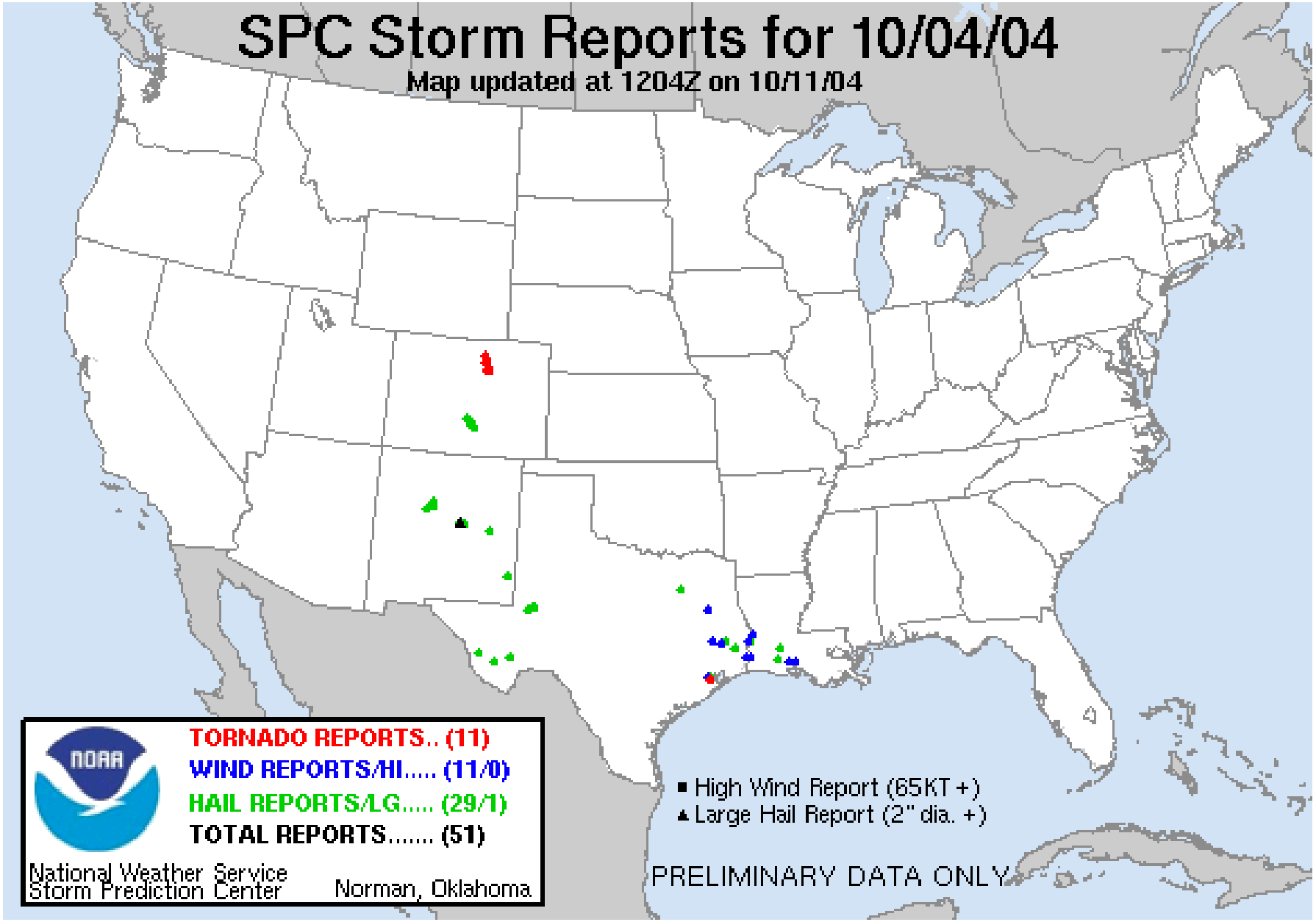
A close look at the velocity (from the KFTG radar) at 2200z – still have the 4 small scale circulations along the DCVZ.

Close call for DIA!

Green is toward, red away.



The tornadoes were the only severe weather near Denver that day.



nice video at https://www.youtube.com/watch?v=3FuuP7uJVEk

Example 6: 18 June 2013 tornado on the DIA runways

- Tornado develops at se edge of DIA and moves to the NW
- Airport terminals evacuated
- Passed right over a couple of LLWS sensors
- First use of total lightning (in-cloud and cloud-to-ground) to help issue a warning with some lead time

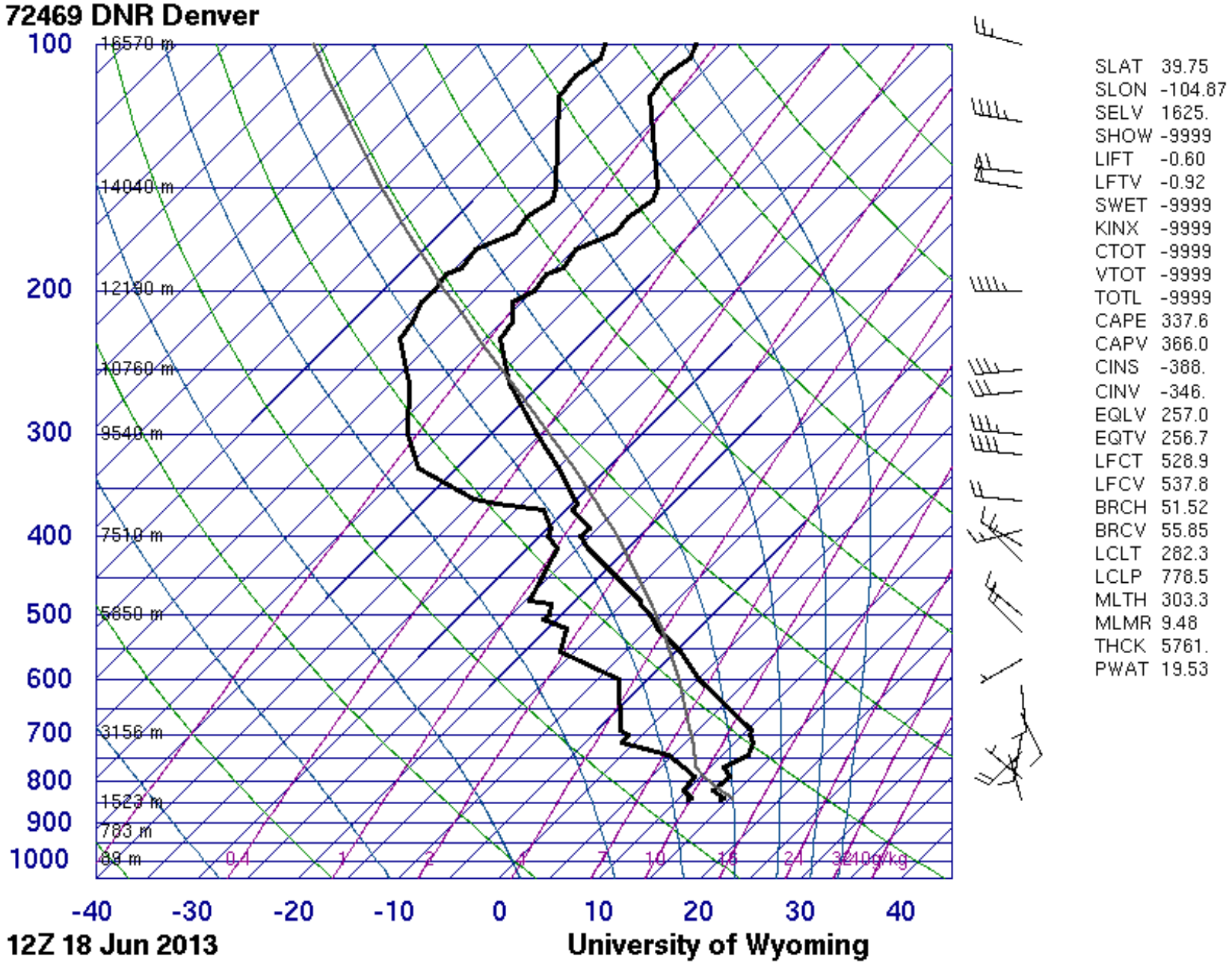
Tornado tracked across the N-S runway area heading towards the terminal

Some views of the tornado

Some views of the tornado

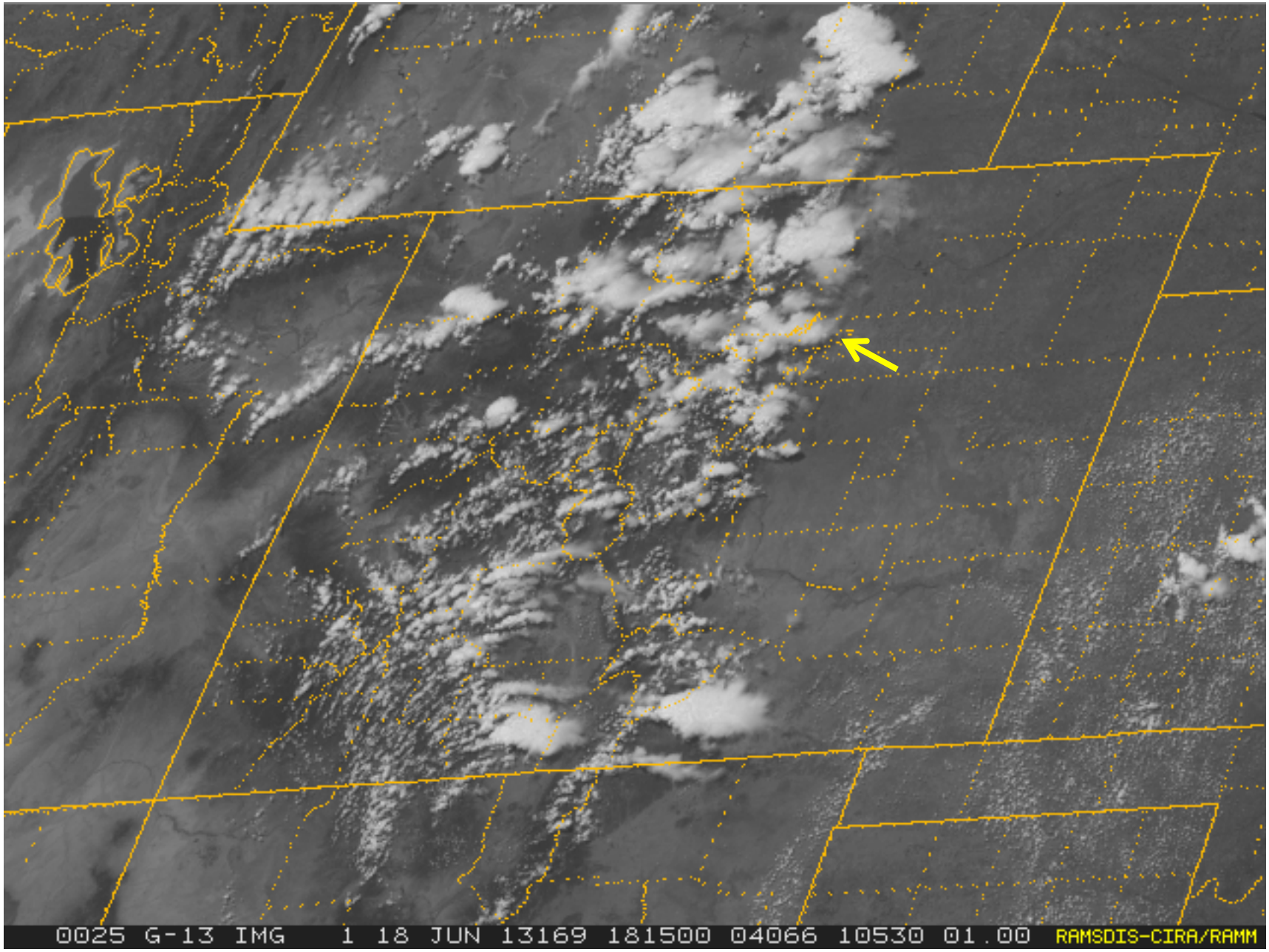
Empty DIA concourse after evacuation to tornado shelters

Denver Sounding at 1200z/0600 MDT on 18 June 2013



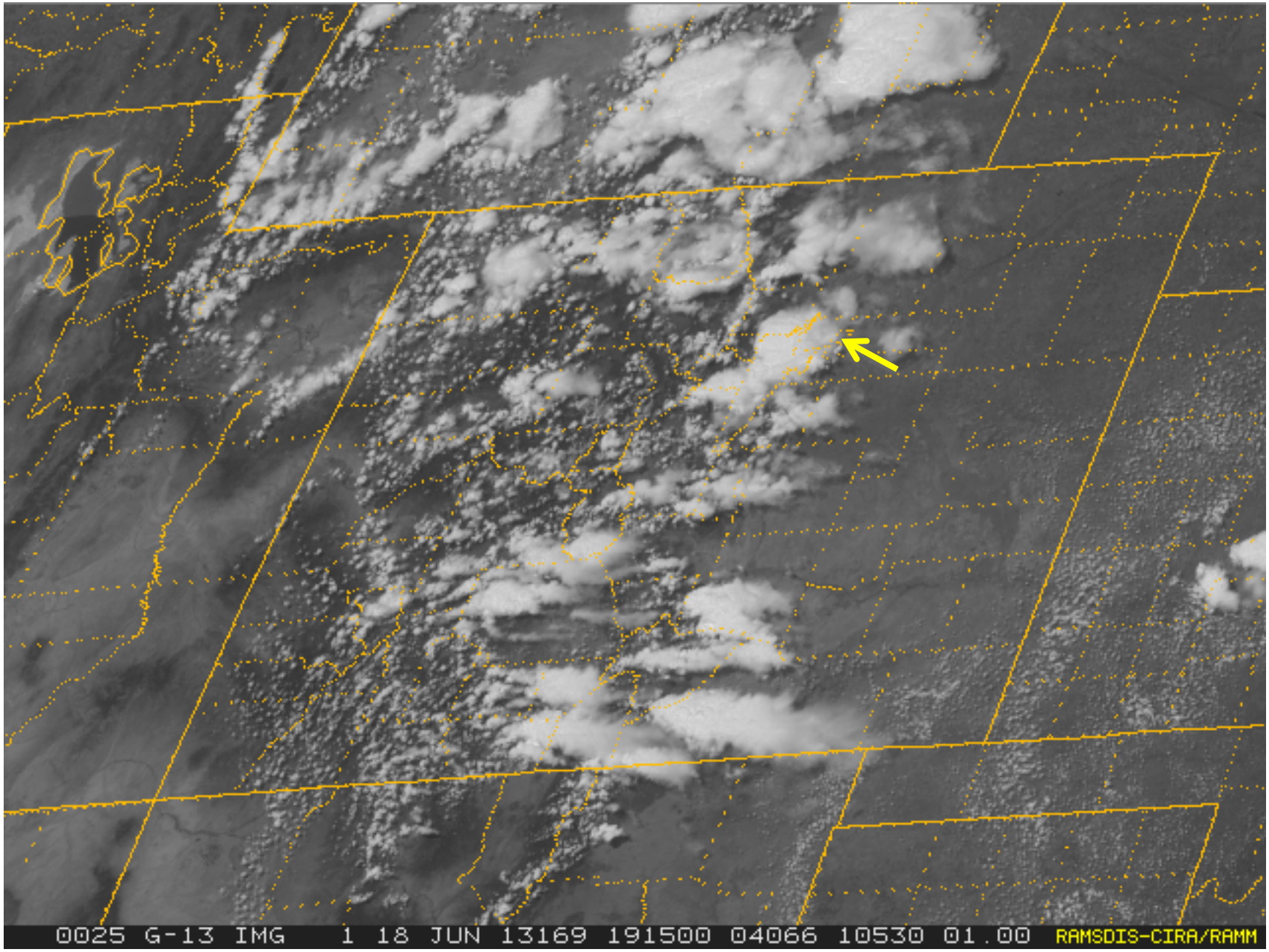
Not much vertical wind shear (but some). Steep lapse rate above the stable layer. Good low-level moisture.

Visible satellite image at 1815z/1215 MDT on 18 June 2013



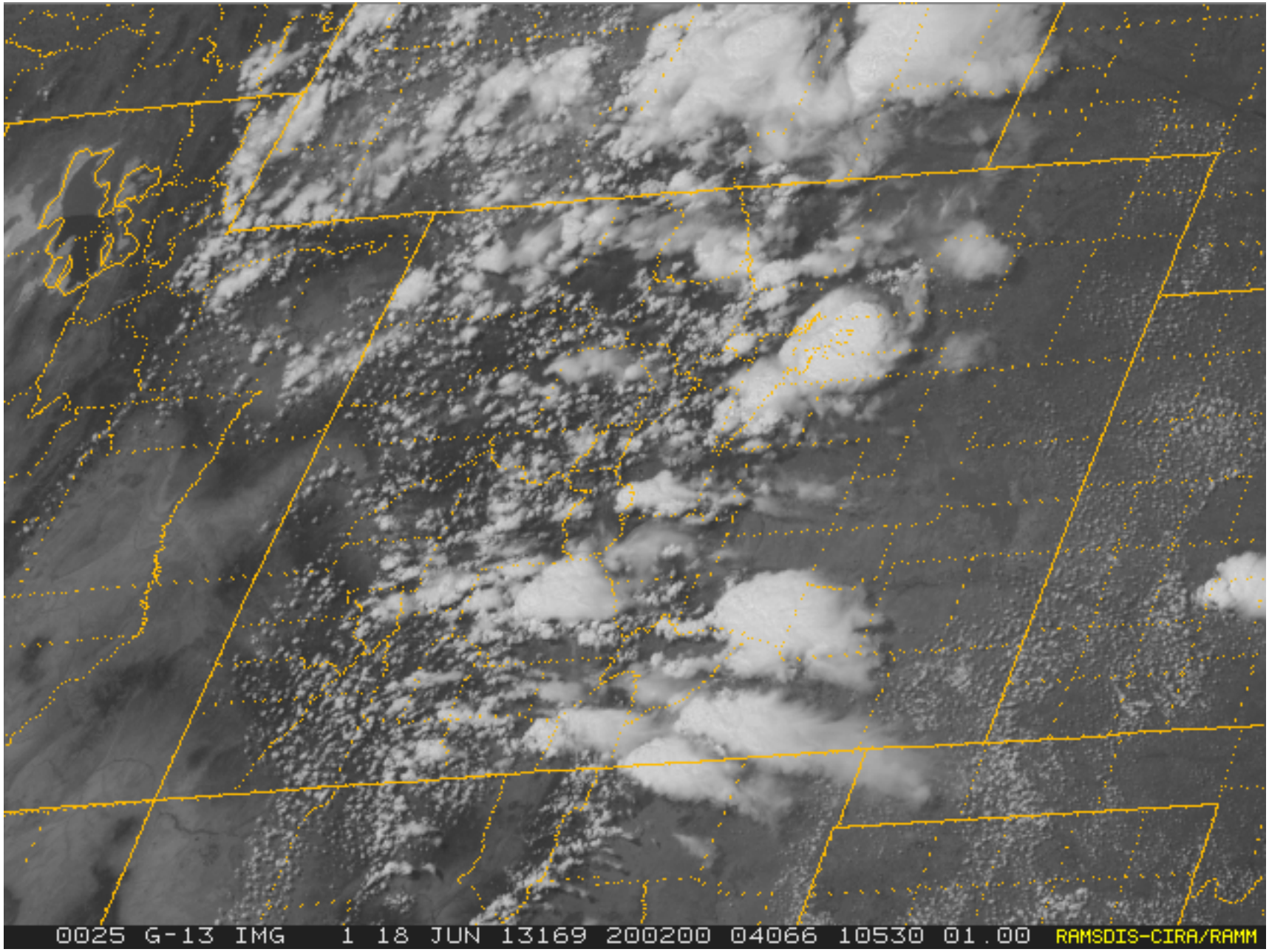
Arrow points to DIA. Initial cells form over the higher terrain.

Visible satellite image at 1915z/1315 MDT on 18 June 2013



Arrow points to DIA. An hour later some cells moving onto the plains, but not all survive.

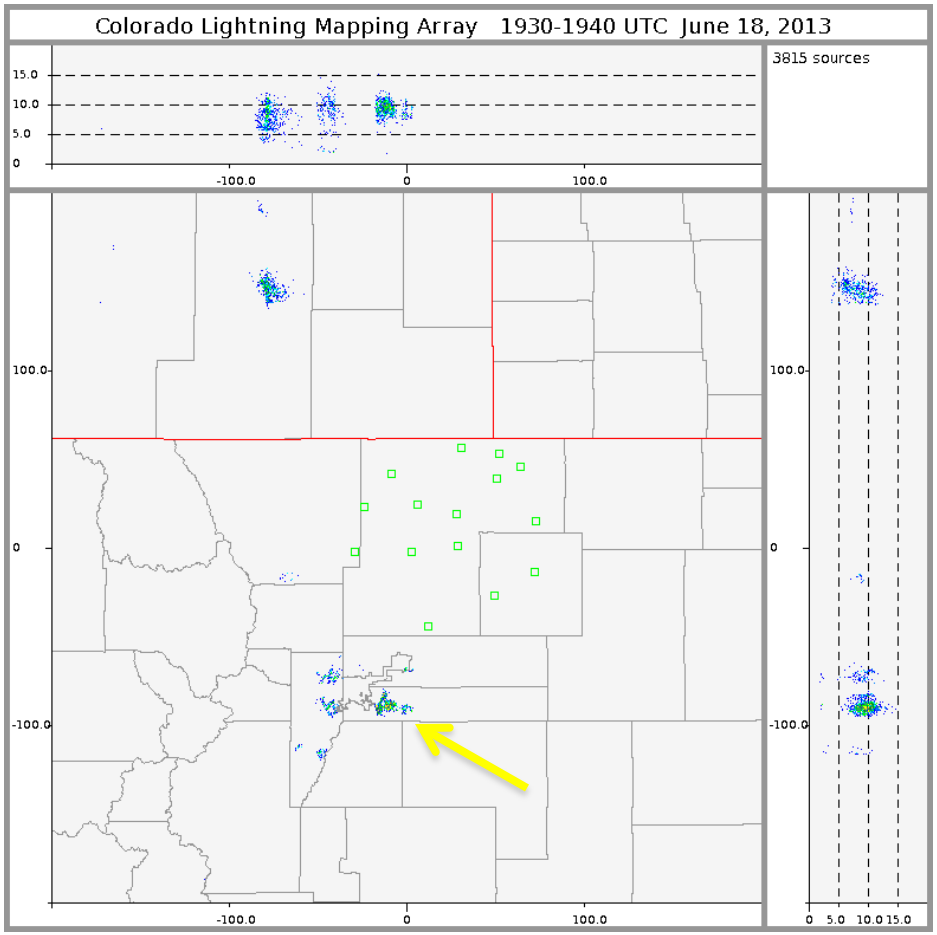
Visible satellite image at 2002z/1402 MDT on 18 June 2013



Arrow points to DIA. Strongest storm develops over the DCVZ, which was basically lying south to north over DIA.

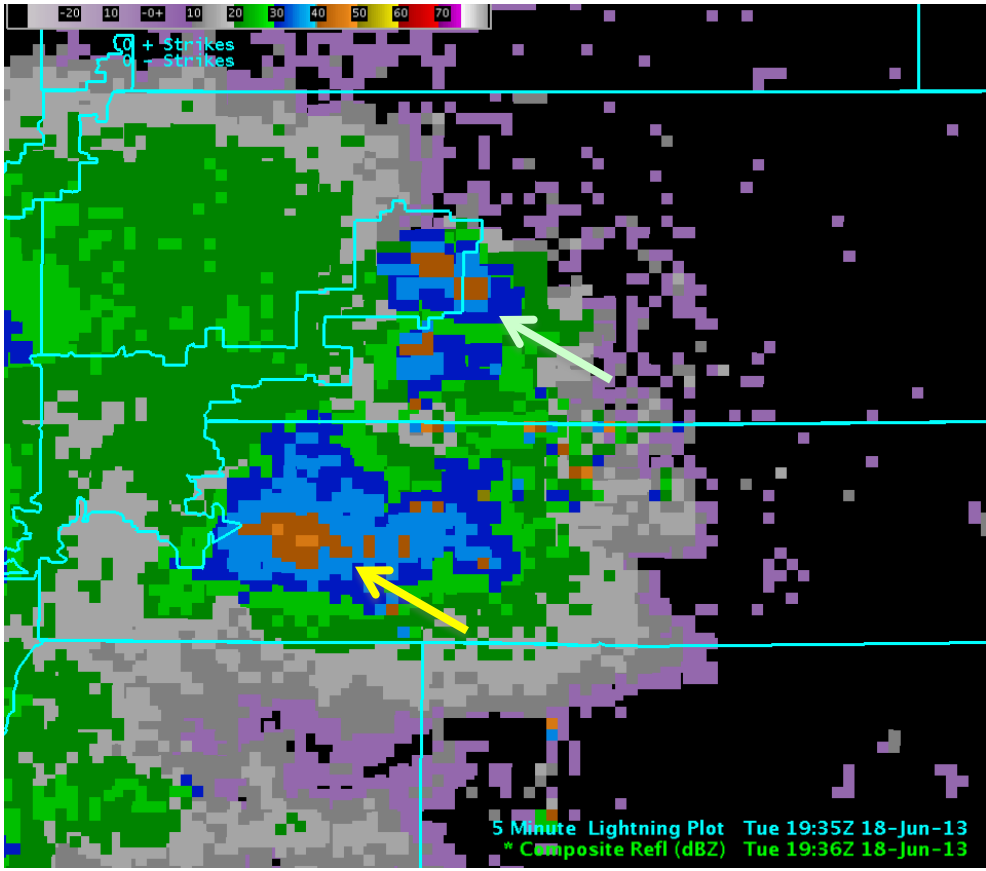
Total Lightning data and the DIA tornado on 18 June

- Radar was very close to the tornado
  - 88D ~7 miles away
  - Terminal Doppler radar (TDWR) ~11 miles away



CO LMA display 1930-40 UTC

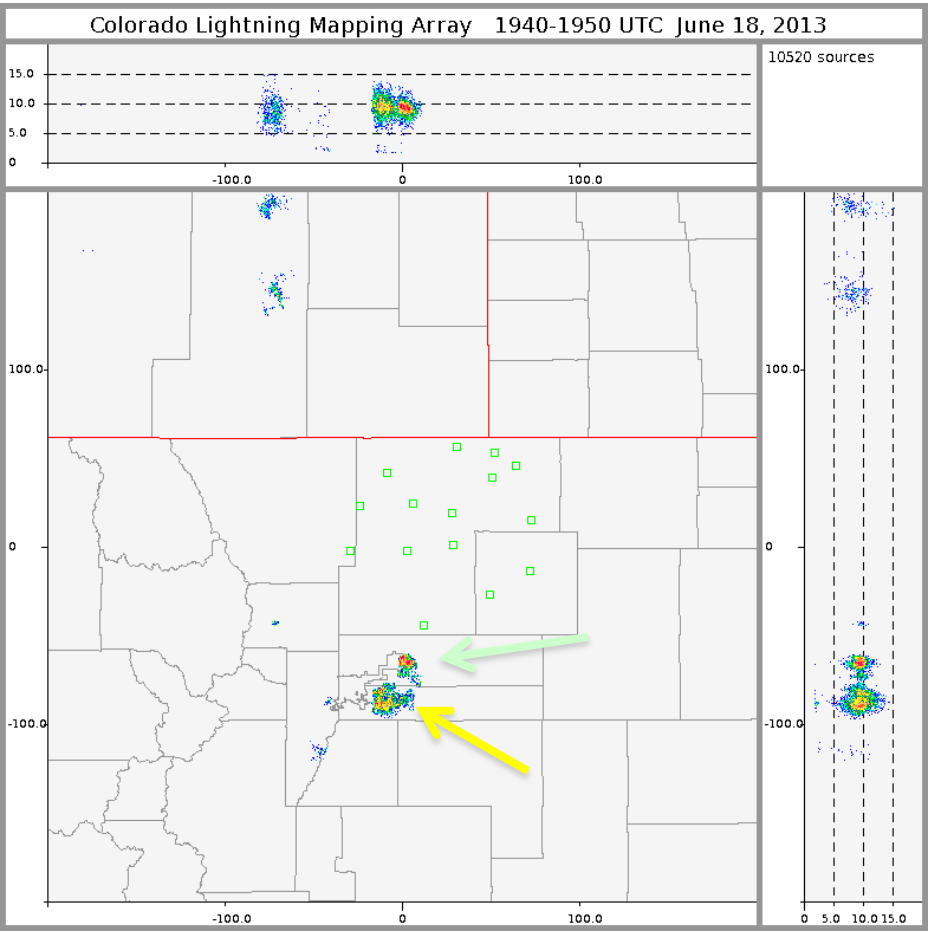
Composite Reflectivity from 88D at 1936



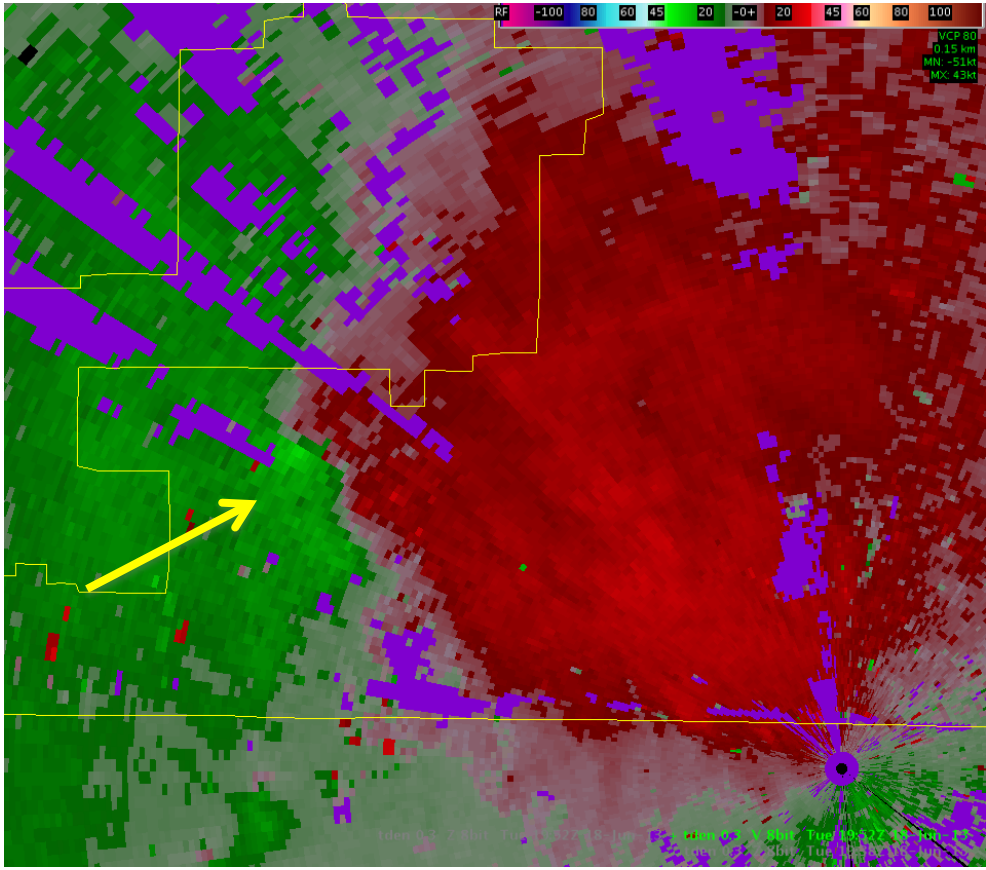
Composite Reflectivity shows echo aloft south of DIA, and in-cloud lightning first seen but already increasing (arrow). No real circulation yet near the surface. Note second weaker cell to the north.

Total Lightning data and the DIA tornado on 18 June

CO LMA display 1940-50 UTC

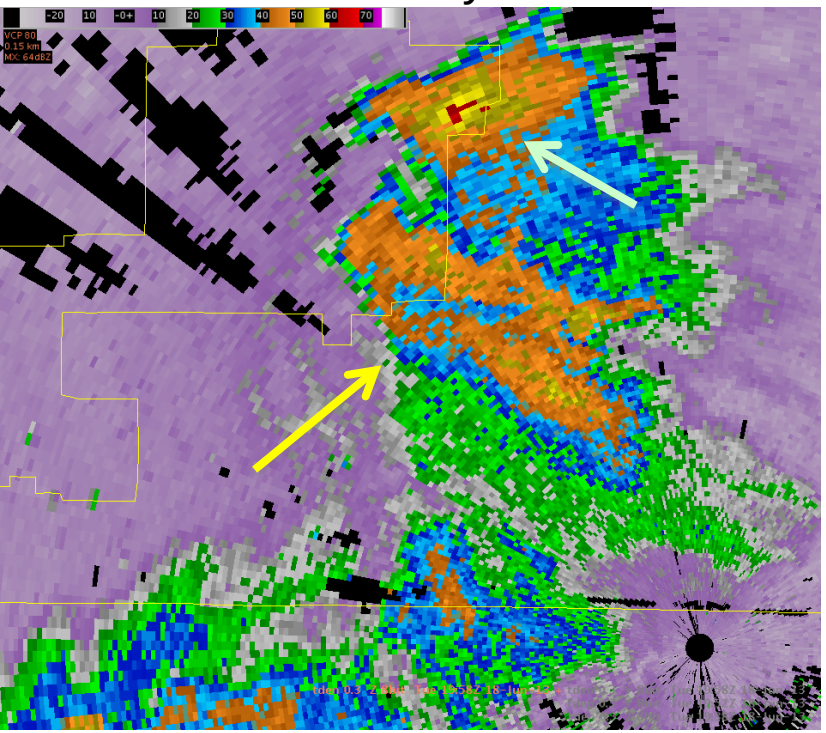


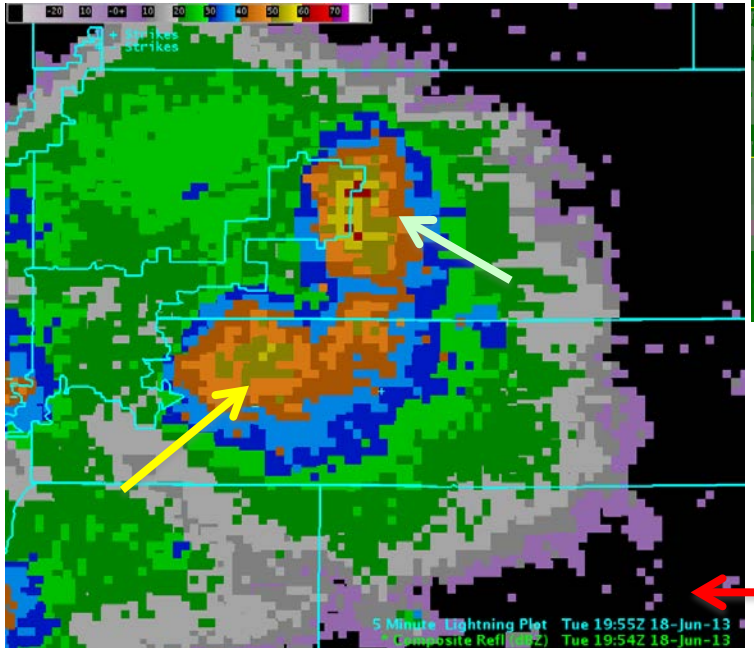
Velocity at 0.3º from TDWR at 1952 UTC



We start to see a circulation near the surface, meanwhile in-cloud lightning increasing rapidly (indicative of increasing updraft – a key to non-supercell tornadogenesis) in the southernmost cell. Now see lightning aloft in the northern cell (over DIA) *(light green arrow)*

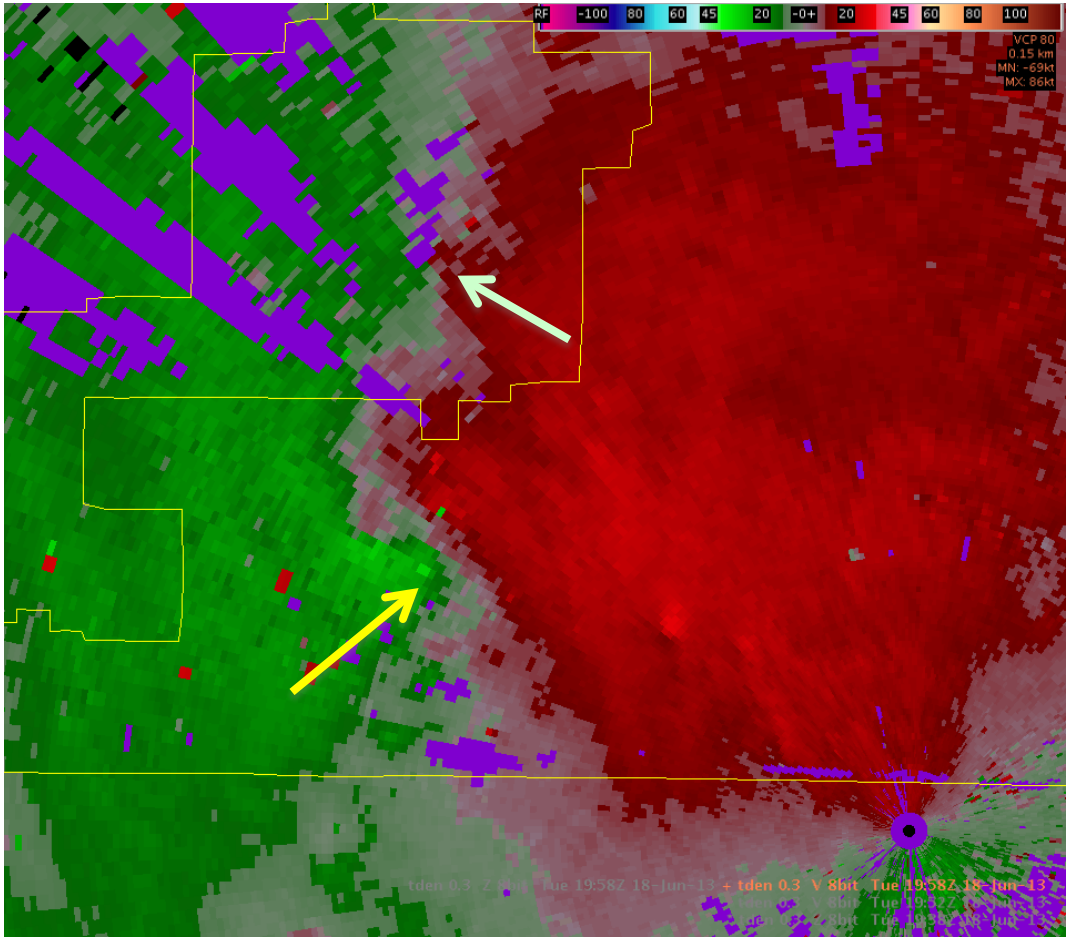
0.3º TDWR reflectivity at 1958 UTC





A few minutes later...

Velocity at 0.3º from TDWR at 1958 UTC

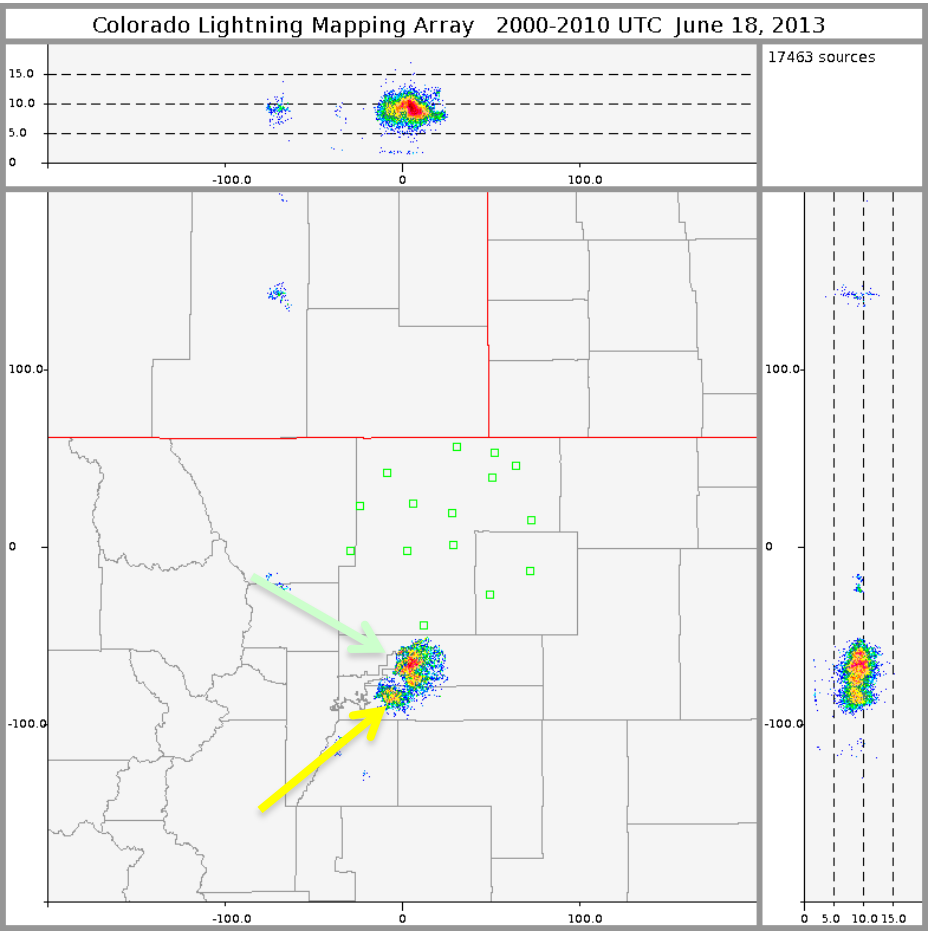


Southern circulation tightens but no tornado forms with this cell. Start to see a circulation with the northern cell.

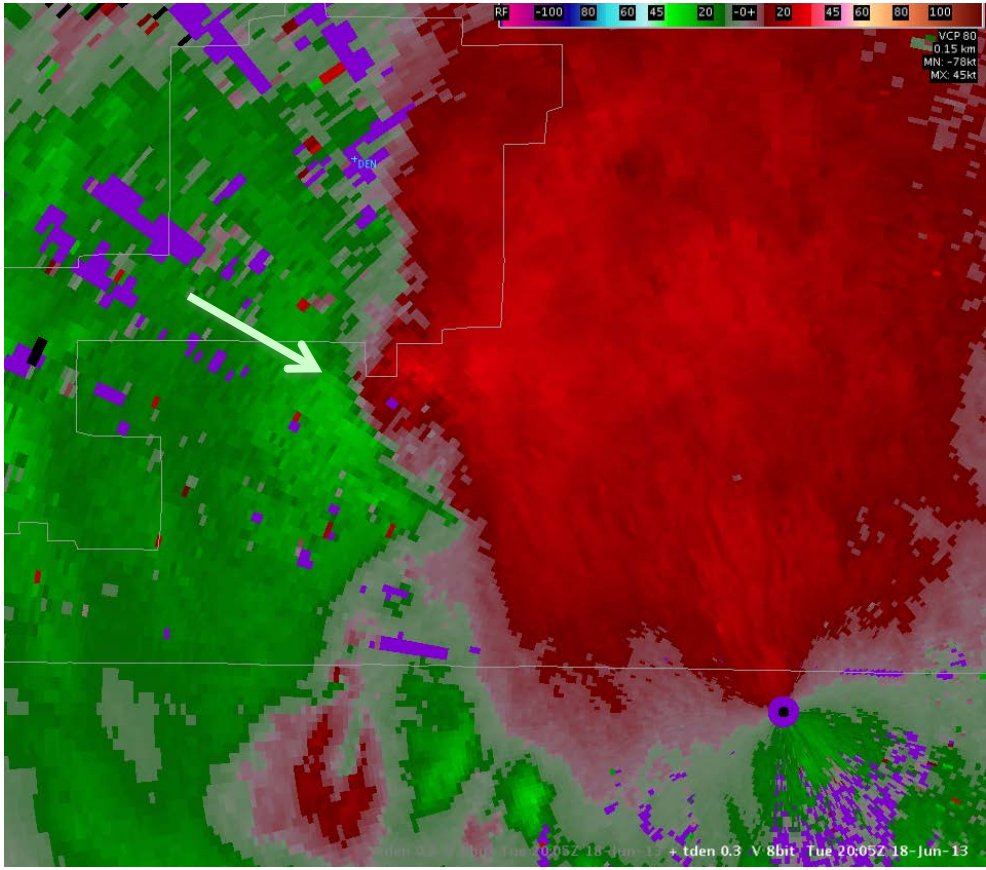
Composite reflectivity at 1954 shows more rapidly growing northern cell

Total Lightning data and the DIA tornado on 18 June

CO LMA display 2000-2010 UTC



Velocity at 0.3º from TDWR at 2005 UTC

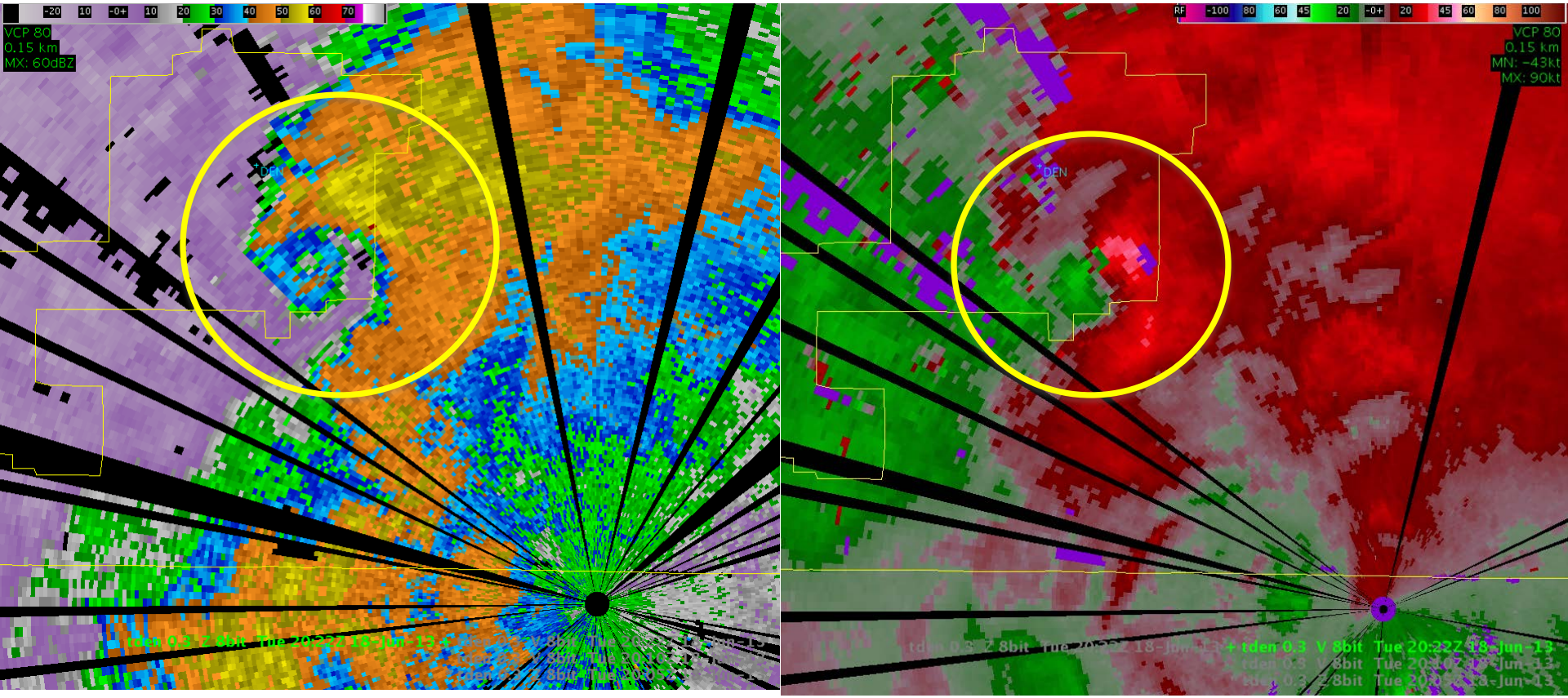


The northern circulation and cell take over, also shown in the total lightning trend, but still no confirmed tornado on the ground (warning is issued shortly after this time). Touchdown not confirmed until 2022 UTC via call to the DIA tower!

Total Lightning data and the DIA tornado on 18 June

Reflectivity at 0.3º from TDWR at 2022 UTC

Velocity at 0.3º from TDWR at 2022 UTC



TDWR reflectivity and velocity image at 2022 UTC when tornado was confirmed by DIA tower. Hook echo is seen in the reflectivity with shear in the velocity image >100 knots. Max velocity from the radar was 90 knots (flow away (red) from the radar).

How predictable are these tornadoes?

HWOBOU HAZARDOUS WEATHER OUTLOOK NATIONAL WEATHER SERVICE
DENVER/BOULDER CO 1050 AM MDT TUE JUN 18 2013 COZ030>051-191700-

.DAY ONE...TODAY AND TONIGHT SCATTERED THUNDERSTORMS WILL DEVELOP AGAIN THIS AFTERNOON AND CONTINUE INTO THE EVENING HOURS. THE BEST MOISTURE AND INSTABILITY WILL BE EAST OF A LINE FROM NEAR GREELEY TO DIA WHERE SEVERE STORMS WILL BE POSSIBLE WITH GOLF BALL SIZE HAIL AND DAMAGING WINDS THE PRIMARY THREAT WITH A TORNADO ALSO POSSIBLE WITH STORMS THAT COULD BECOME MORE ORGANIZED AS THEY MOVE EAST. FARTHER WEST...BRIEF HEAVY RAIN...SMALL HAIL AND WIND GUSTS TO 50 MPH WILL BE POSSIBLE FROM THE THUNDERSTORMS. IN ADDITION...A WEAK DENVER CYCLONE HAS ALREADY FORMED AND THIS SHOULD STRENGTHEN INTO THE EARLY AFTERNOON WITH THE STRONGEST CONVERGENCE RUNNING SOUTH TO NORTH NEAR DIA. ALONG THIS BOUNDARY STORMS COULD BECOME LOCALLY MORE INTENSE WITH A NON SUPERCELL TORNADO POSSIBLE. STORMS WILL DEVELOP IN THE FOOTHILLS BY LATE MORNING AND THEN ON THE PLAINS DURING THE AFTERNOON.

Enough confidence for this case (June) to put in the HWO

Closing thoughts...

Local

Airport site in tornado-prone area

Meteorologist's report not likely to change site

By JAMES G. WRIGHT
Rocky Mountain News Staff Writer

Denver's new airport will be built in an area prone to thunderstorms, tornadoes and deadly windshear that can knock planes out of the air, according to a meteorologist's report released yesterday.

Airport planners acknowledged that weather at the site is more turbulent than at Stapleton but said the differences are minor and present no safety problems.

The weather study was prepared under a city contract by meteorologist William P. Mahoney, of the University Corporation for Atmospheric Research in Boulder.

"Focused studies suggest that the new airport site may have more thunderstorm, tornado and high-wind events than Stapleton," Mahoney said.

In the report, Mahoney determined that the 52-square-mile proposed airport site 12 miles northeast of Stapleton International is in the center of a weather phenomenon called the Denver Convergence Zone.

The zone, which normally lies east of Stapleton, runs parallel to the Front Range where dry winds from the southwest collide with cooler, moist mountain air.

At the point of convergence, the winds often create tornadoes, thunderstorms and microbursts of intense, downward blasts of air known as windshears that are strong enough to knock large planes to the ground.

Windshear conditions have been blamed for several major air disasters in recent

MARK MATTERN/Rocky Mountain News

operations at least 140 days of the year. Wind direction data, for example, will help

"I can't say the new airport is a bad site, there's no evidence pointing to that," Mahoney said in an interview. "There are differences (from Stapleton), but they should not affect operations significantly enough to warrant changing the site."

Opponents of the airport project have raised concerns about tornadoes in testimony at recent environmental impact hearings. Mahoney found that three tornadoes were seen on the proposed airport site from 1981 through 1986, compared with four tornadoes that passed near, but did not touch, Stapleton during the same time.

Last week, another tornado was sighted in what will be the terminal area of the new airport.

Relocating the airport would not avoid the tornadoes that are relatively common northeast of Denver and could add to weather problems, Mahoney said.

The airport cannot be moved west because of the mountains. Sites farther east still would be plagued by tornadoes and would be in blizzard areas, Mahoney said.

The worst hail zone in the state is north of the proposed site, and thunderstorms are so common south of Denver that only one other place in the nation — Miami — records more in a year, Mahoney said.

Airport planners say any weather problems at the proposed site can be countered with sophisticated weather detection systems — such as Doppler radar used to detect windshear — now in development.

"Recent scientific and technological advancements make it possible to address a number of weather-related factors important to airport operations," James W. "Skip" Spensley, director of the city's new airport development office, said in a written statement.

The FAA is developing a terminal weather information system that would integrate

12 June 1988 Rocky Mountain News (3 days before the tornado hits Stapleton!)

- AT THE TOWER, ONE CAN SEE LINE OF CLOUDS GROWING ALONG THE DCVZ: IF SO, BE ON THE LOOKOUT FOR TORNADO FORMATION
- MONITOR KFTG RADAR FOR VORTEX SIGNATURE
- IF PRECIPITATION IS DUMPING OUT, THEN THAT LOCATION IS UNLIKELY FOR NEW TORNADO FORMATION; TORNADO MOST LIKELY PRIOR TO FORMATION OF PRECIPITATION
- MOVEMENT OF TORNADO: DOES STORM REMAIN ANCHORED TO DCVZ OR DOES IT ACQUIRE A LIFE OF ITS OWN AND MOVE AWAY?

- LOOK FOR DCVZ LOCATION FOR POSSIBLE GROWING CUMULUS CONGESTUS CLOUDS: USE VISUAL OBS, RADAR, AND SFC OBS
- IF LOCATION OF GROWING CLOUDS IS NEAR DIA, BE EXTRA VIGILANT
- IF TORNADO FORMS, BE AWARE OF ITS MOTION (OBVIOUS!)
- ONCE PRECIPITATION HAS DUMPED OUT, FORGET ABOUT THAT LOCATION AND LOOK ELSEWHERE FOR POSSIBLE TORNADO FORMATION
- THERE MAY NOT BE A CONDENSATION FUNNEL: LOOK FOR DUST WHIRLS AT THE SFC BEING LOFTED; CONDENSATION FUNNEL OFTEN FORMS AFTER TORNADO HAS BEGUN AT THE GROUND

- SEE *Severe Convective Storms and Tornadoes,* 2013, by H. Bluestein, Springer, pp. 340 – 341, for mobile Doppler radar imagery and photos of

a landspout during VORTEX2 (Fig. 6.27)

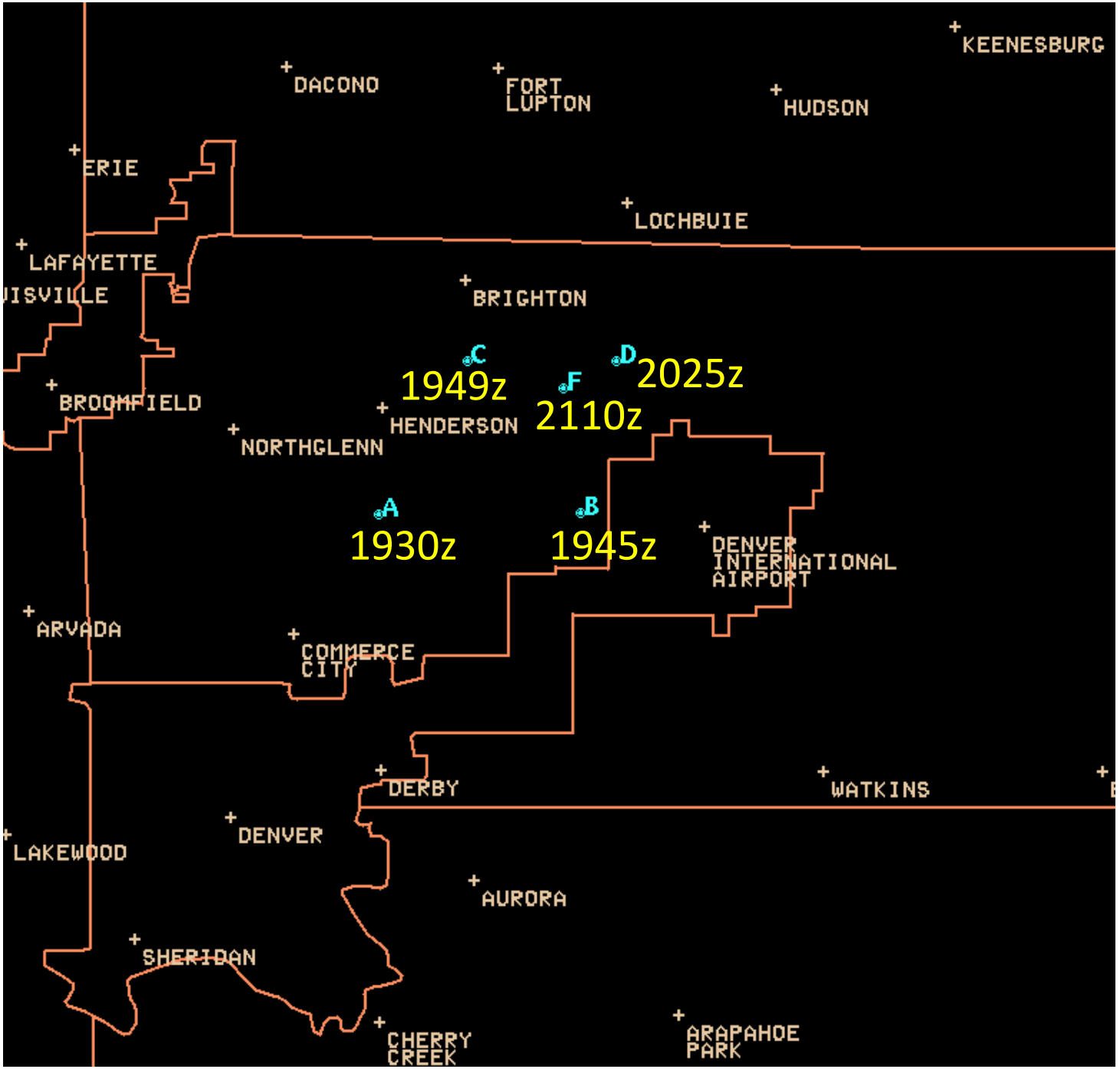
End

Wall cloud as the storm passes near DIA – not sure of the time of this photo.

26 May 2010 – strong storms develop on the DCVZ near DIA (pre VORTEX-2 part)

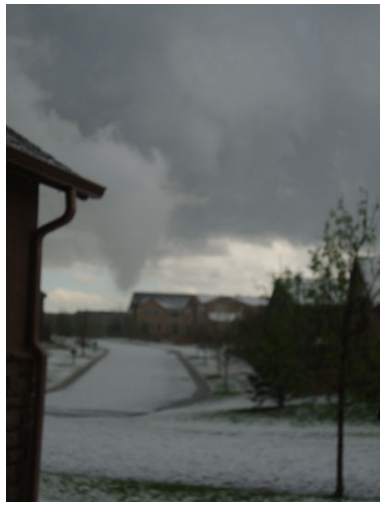
Approximate locations of the tornado reports

5 tornadoes?
Or none?
Officially one
(then another in Weld County that is not shown here)



Some storm photos – scud or wall cloud? Or funnel? Or tornado??

2 photos of lowering over DIA



2 more photos from near DIA

Photo from Hudson

2 photos from Lochbuie

Photo from Wiggins

2 photos from Keenesburg

Photo from Watkins

Hail was a big issue with the storm (and subsequent storms)

Areal view of the hail swath near DIA

Case 2: Landspouts on 16 Aug 2010

Tornadoes north of Gary
2154Z and 2217Z

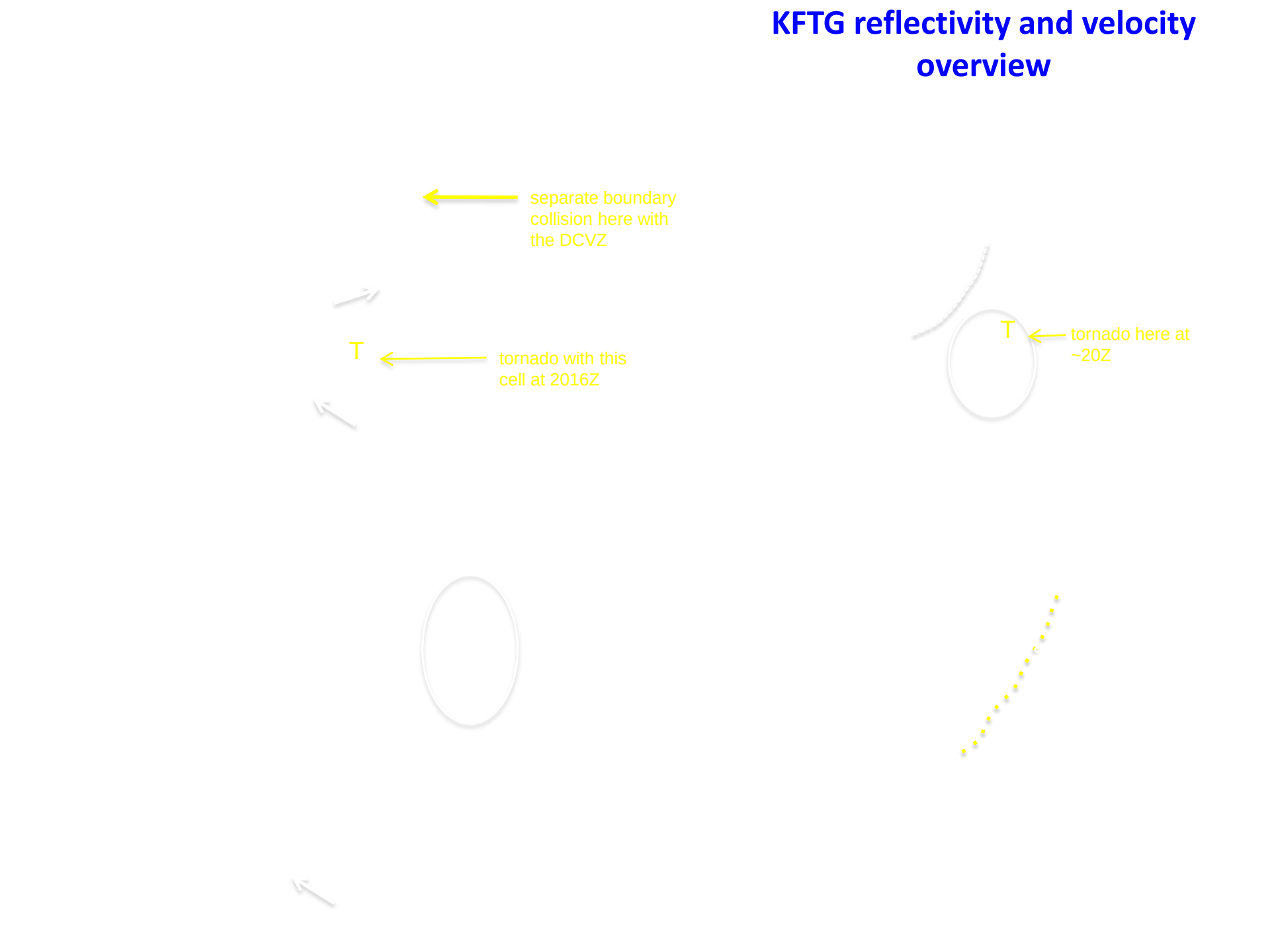
3 SW Agate tornado – 2016Z

Deer Trail tornado – 1957Z

Interstate Highways
Cities
State Boundaries
County Boundaries

KFTG reflectivity and velocity overview

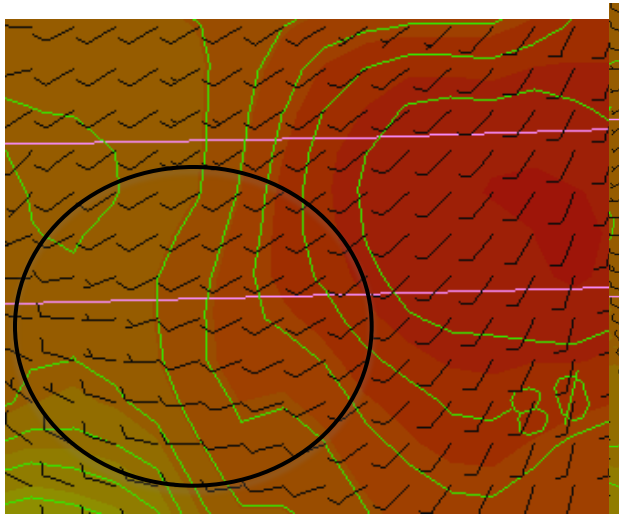
KFTG reflectivity and velocity overview



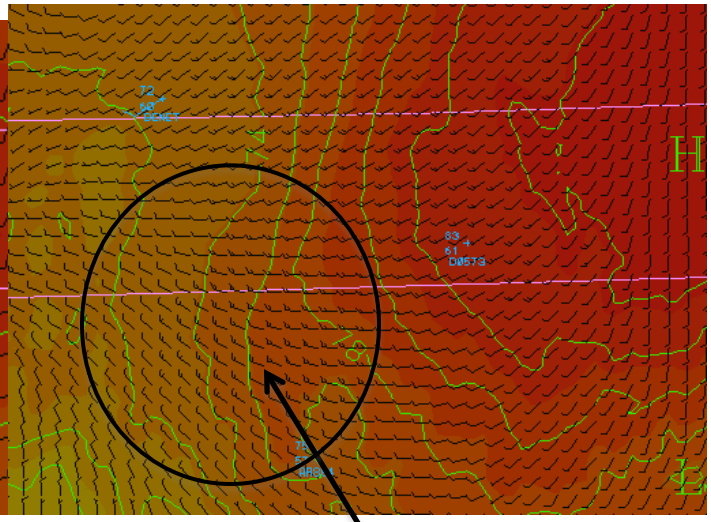
KFTG reflectivity and velocity overview

Wind analysis comparison at 2000z– LAPS/1km (which uses Doppler winds) has the strongest NW winds in the circled area closer to what the Doppler velocity indicated. Others tend to be too light, though of these HRRR comes appears to come closest. Very few obs in area circled.

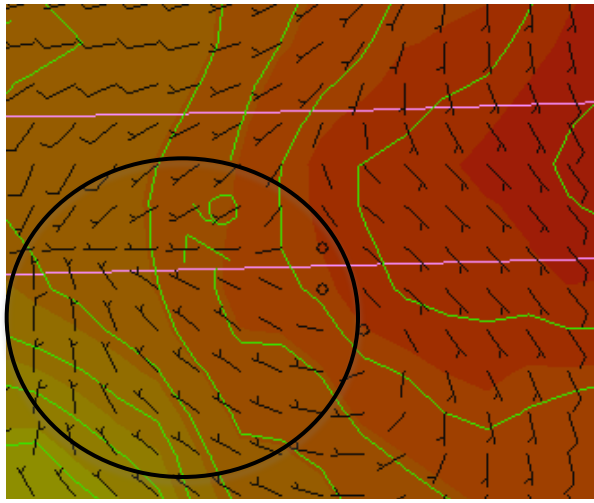
LAPS/5 km



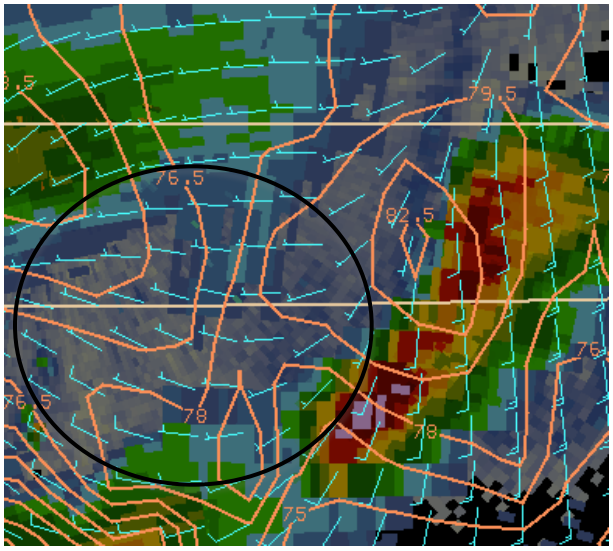
LAPS/1 km



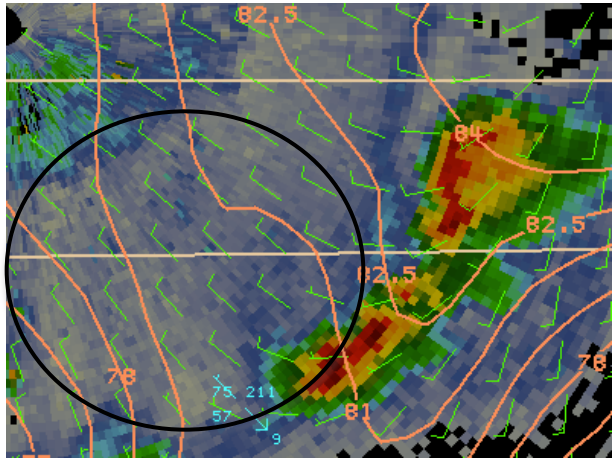
STMAS

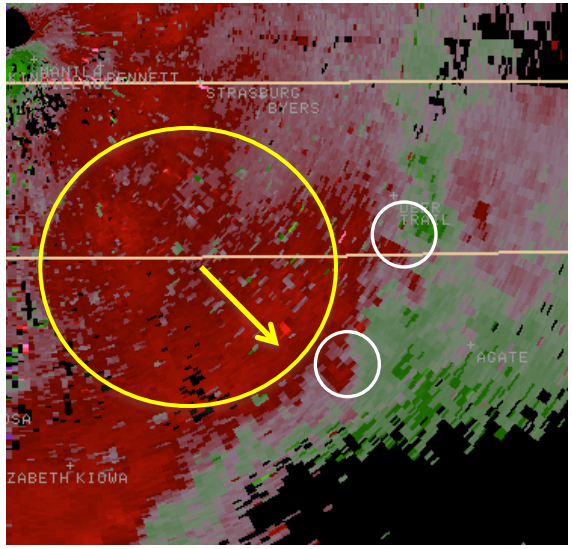


RTMA



HRRR





KFTG velocity

Did LAPS at 1 km resolve the (pre-)tornadic vortices along the DCVZ?

Looks like it did, but, annoying line of concentrated vorticity east of where the action is.