
Synoptic Regulation of the 3 May 1999 Oklahoma Tornado Outbreak
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(Jarboe)
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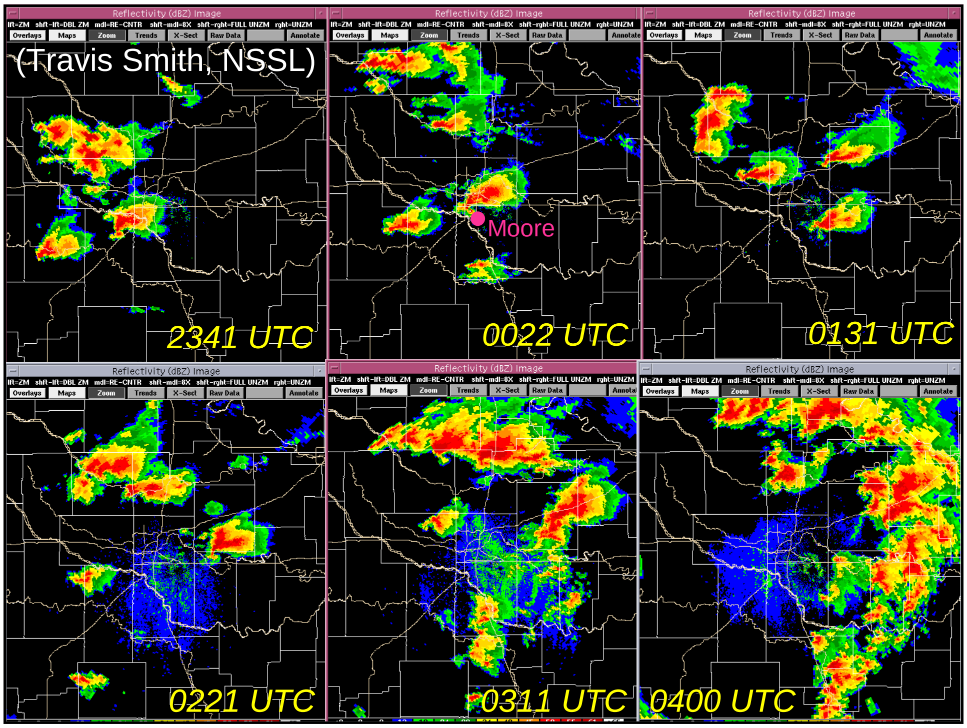
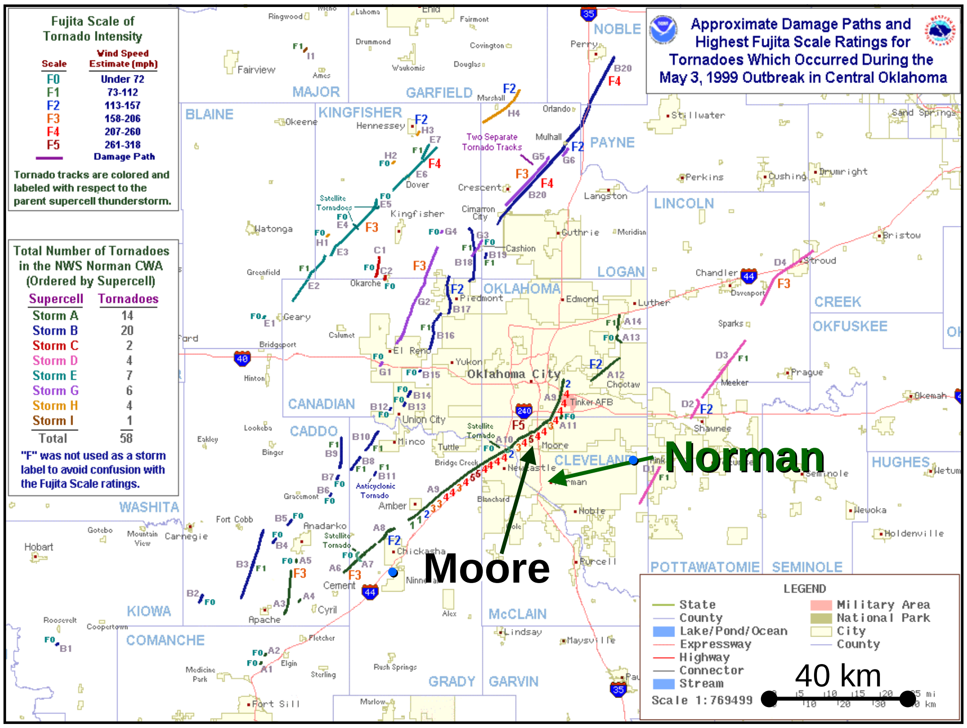


The Outbreak: Facts

- 66 tornadoes, produced by 10 long-lived and violent supercell thunderstorms
- Oklahoma City's first F5 tornado
- Almost 2300 homes destroyed and 7400 homes damaged
- Over $1 billion in damage, the nation's most expensive outbreak
- 45 fatalities, 645 injuries in Oklahoma
- About 500–700 expected fatalities in days before outlook/watch/warning system (Brooks)



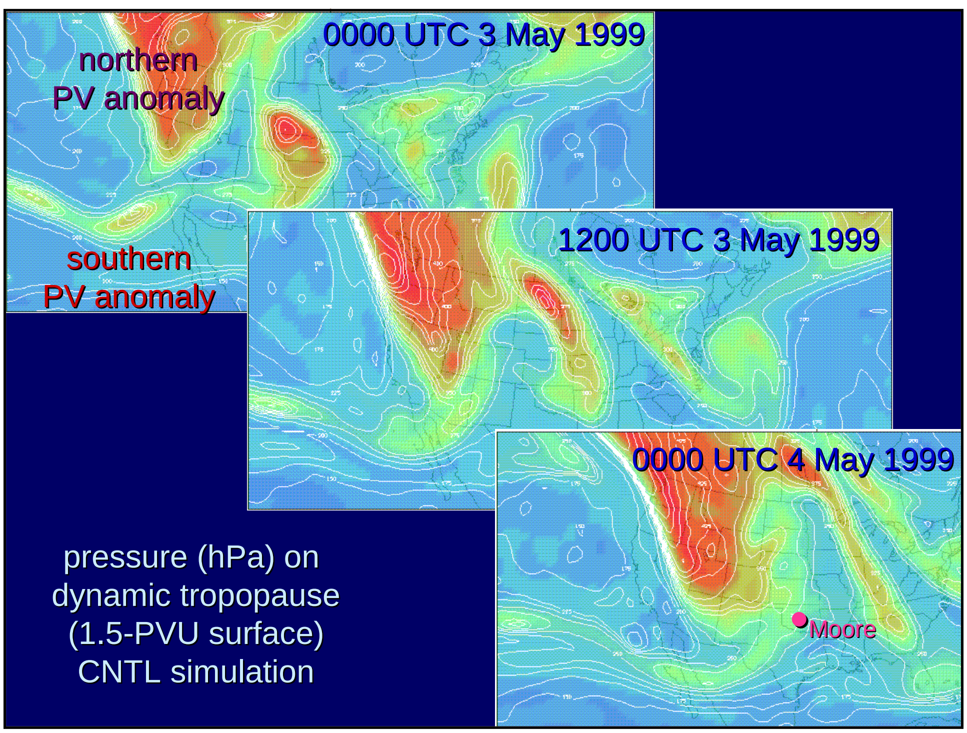
Forecast Success

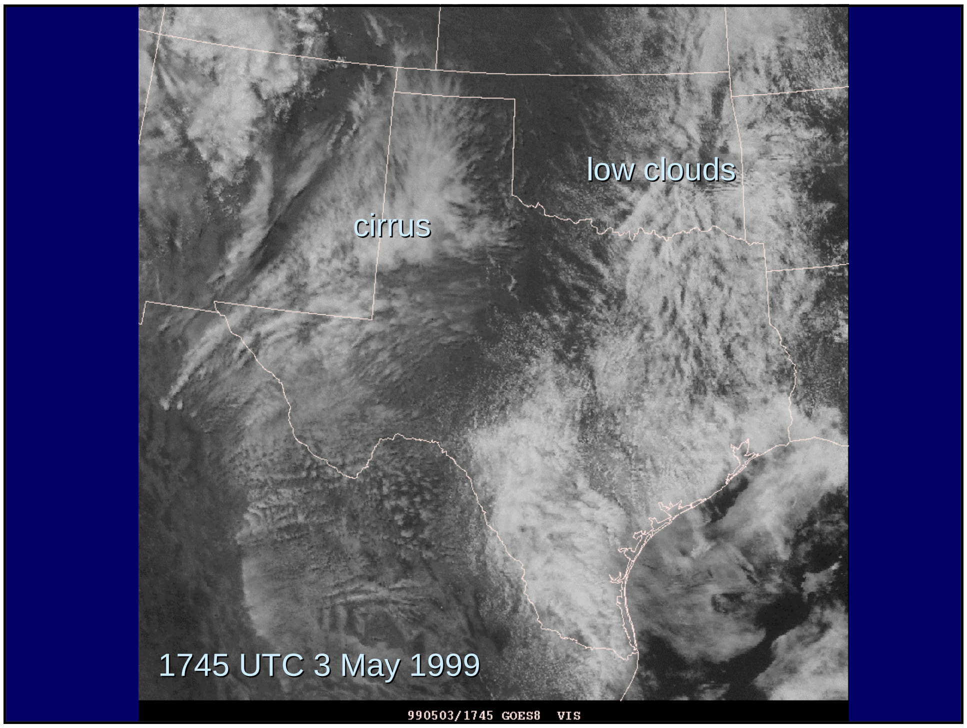
- Forecasts from the Storm Prediction Center were updated as forecaster confidence grew
- First tornado watch preceded the F5 tornado by **2.5 hours**
- The Forecast Office in Norman, Oklahoma, issued **31** severe thunderstorm and **48** tornado warnings with **48** mins. of avg. lead time for F2 and greater tornadoes (18 mins. lead time for all tornadoes)

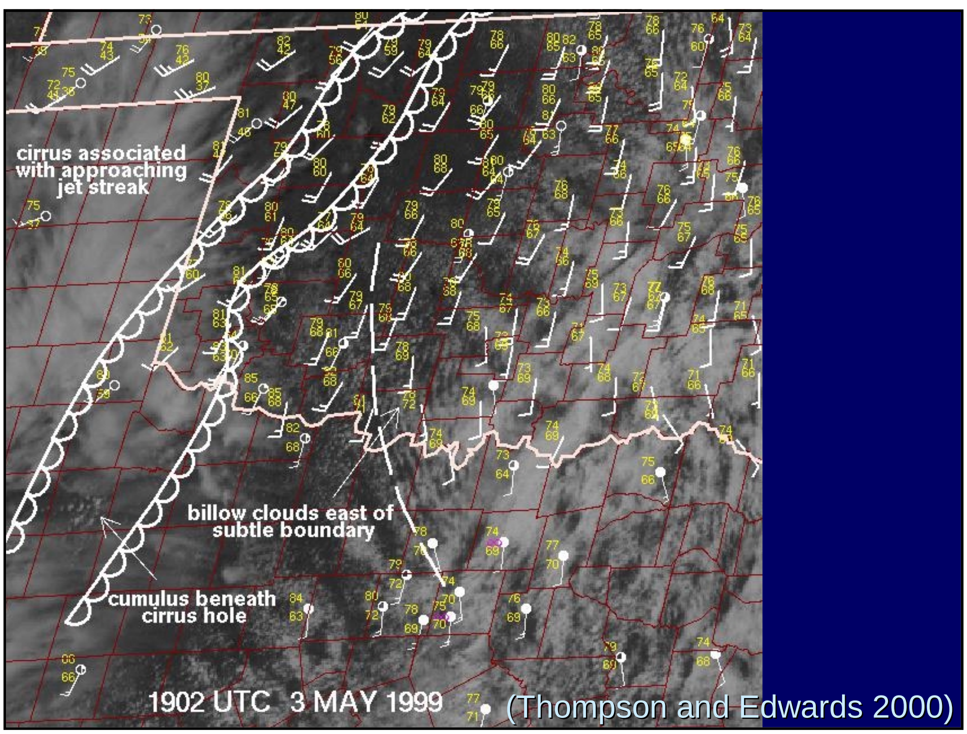
(NWS)

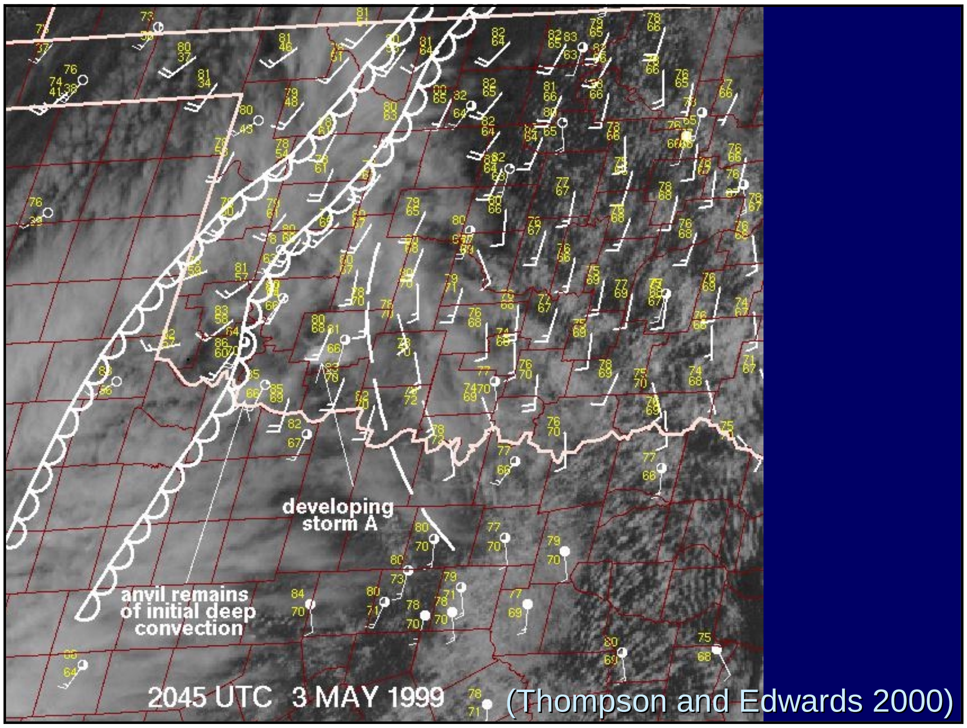
Despite the Successes, Considerable Uncertainty Existed Among Forecasters

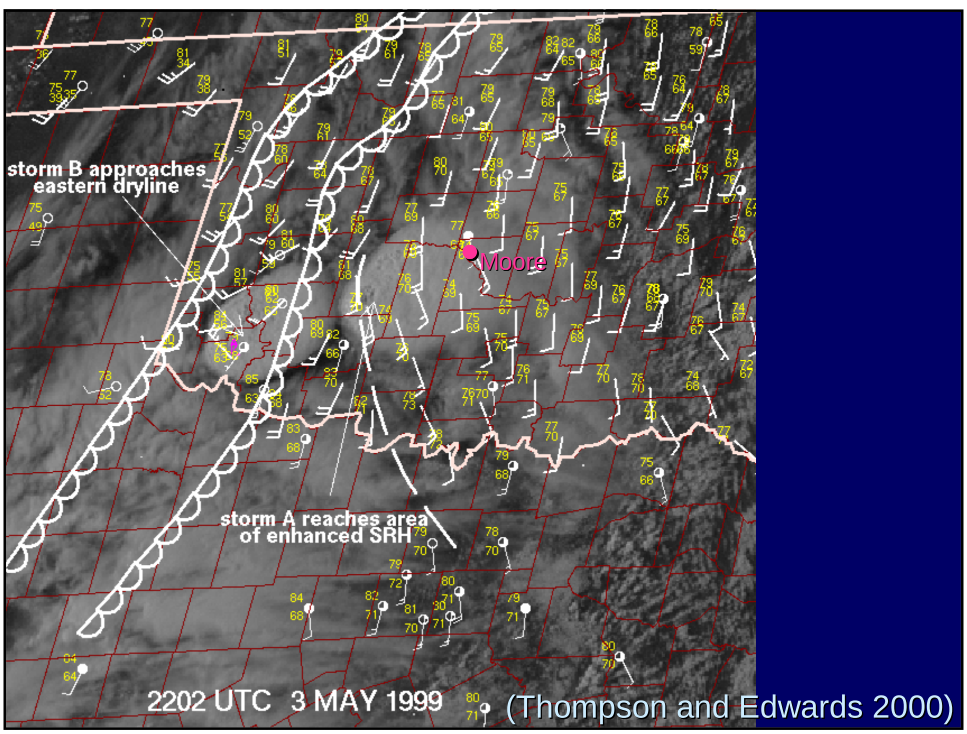
- Jet streak/shortwave trough (PV filament or southern PV anomaly)
  - initial and forecast strength of this feature
- Cirrus
  - Would the cirrus inhibit destabilization?
  - Associated with tropospheric-deep ascent?
- Dryline
  - diffuse, with weak surface convergence

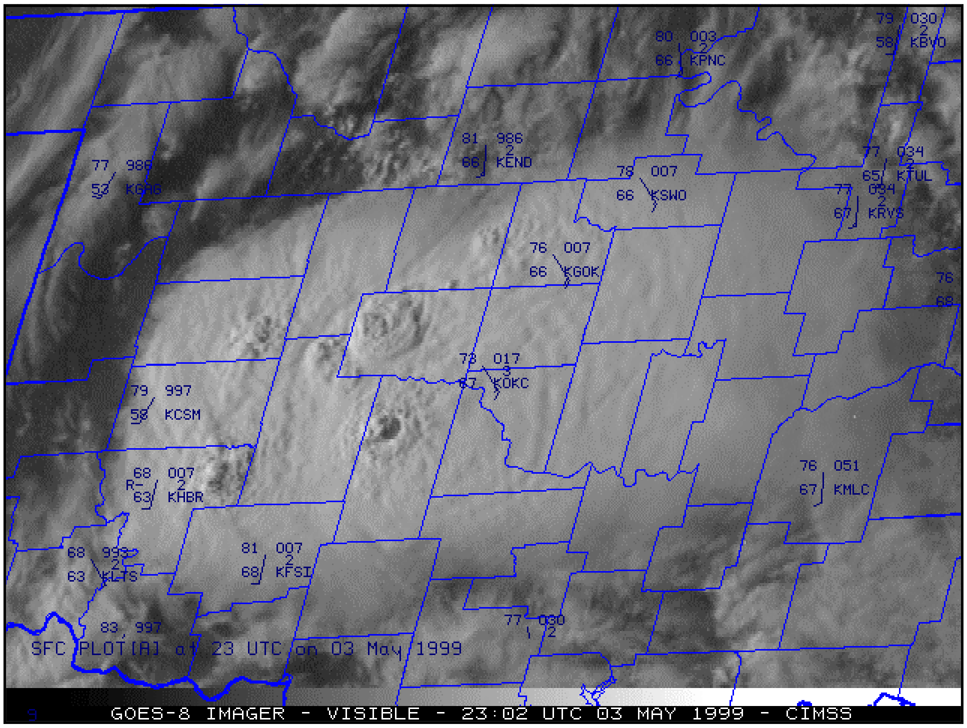



low clouds
cirrus
1745 UTC 3 May 1999
990503/1745 GOES8 VIS


cirrus associated with approaching jet streak
billow clouds east of subtle boundary
cumulus beneath cirrus hole
1902 UTC 3 MAY 1999
(Thompson and Edwards 2000)


developing
storm A
anvil remains
of initial deep
convection
2045 UTC 3 MAY 1999
(Thompson and Edwards 2000)


storm B approaches
eastern dryline
Moore
storm A reaches area
of enhanced SRH
2202 UTC 3 MAY 1999
(Thompson and Edwards 2000)



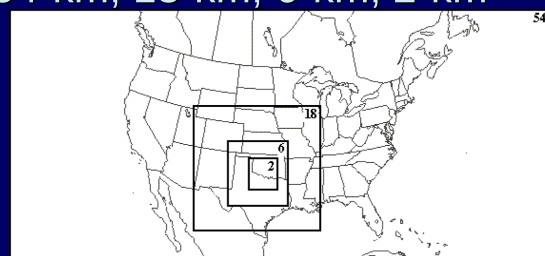
Objective

Through observations and numerical-modeling investigations, explore the impact of the three processes hypothesized by forecasters to be important in the outbreak: **dryline**, **cirrus**, **and PV filament**.

Modeling experiments: We're not considering explicit prediction of the supercells, but investigating the environment in which they formed.

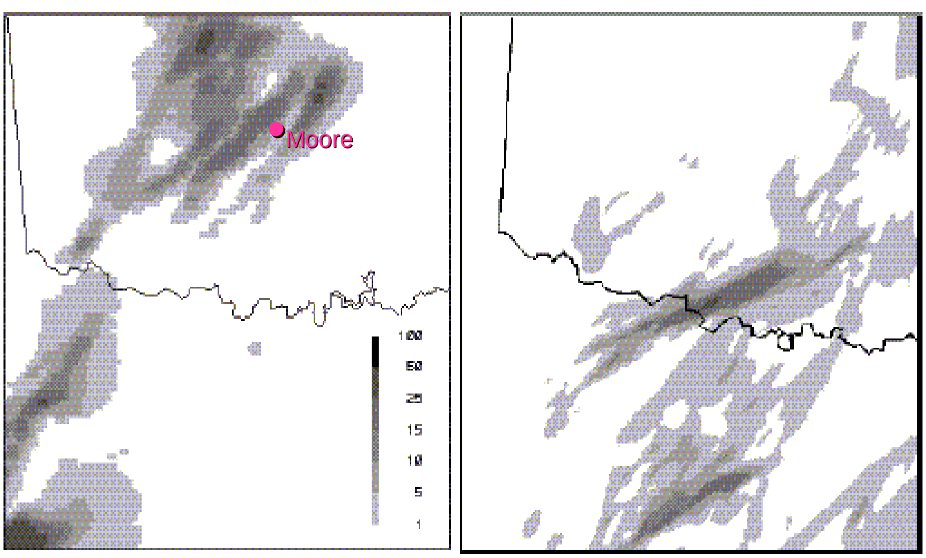
Model Characteristics

- MM5: cold start with initial and lateral conditions provided from the 0000 UTC 3 May forecast cycle of the AVN
- 4 domains: 54-km, 18-km, 6-km, 2-km
- 23 levels



- Reisner, Kain–Fritsch (outer two domains), Blackadar PBL, cloud radiation every 2 min, 5-layer soil model

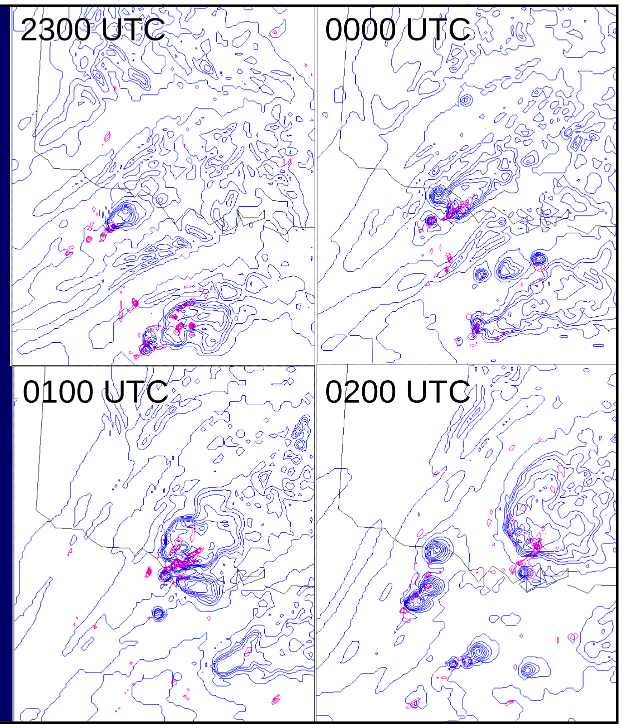
PRECIPITATION: 1800 UTC 3 MAY TO 0300 UTC 4 MAY (mm)



OBSERVED   CONTROL SIMULATION

Stage IV Radar/Gauge Precip. Analysis (Baldwin and Mitchell 1997)

CNTL d4

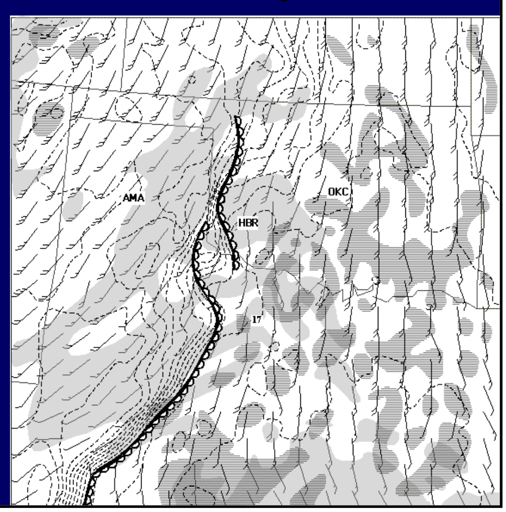


pink:
1.5-km *w*
(> 0.5 m/s)

blue:
9-km
cloud-ice
mixing ratio
(>0.1 g/kg)

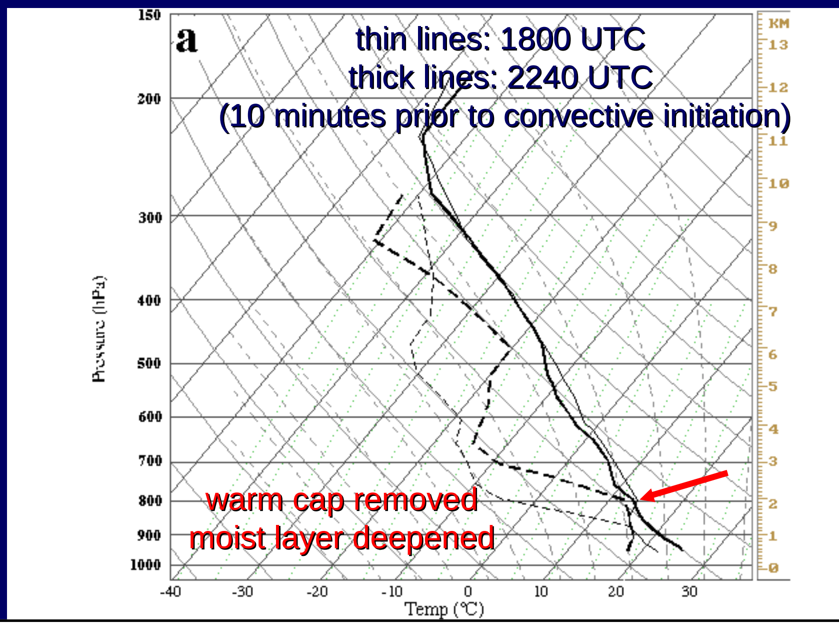
PBL Similarities: Observed and Model

- Convection initiated within relatively homogeneous air mass
- Diffuse/double dryline
- “Billow” clouds



2100 UTC 3 May:
surface dewpoint (every 2°C), vertically integrated cloud water and cloud ice

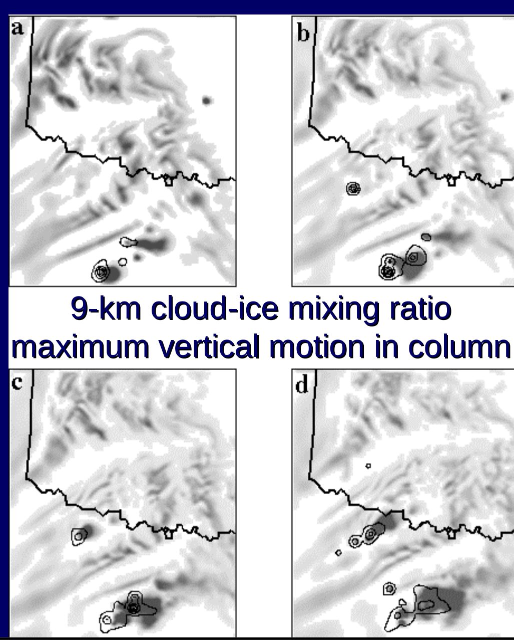
Convective Initiation



Convective Initiation in Cirrus Gaps

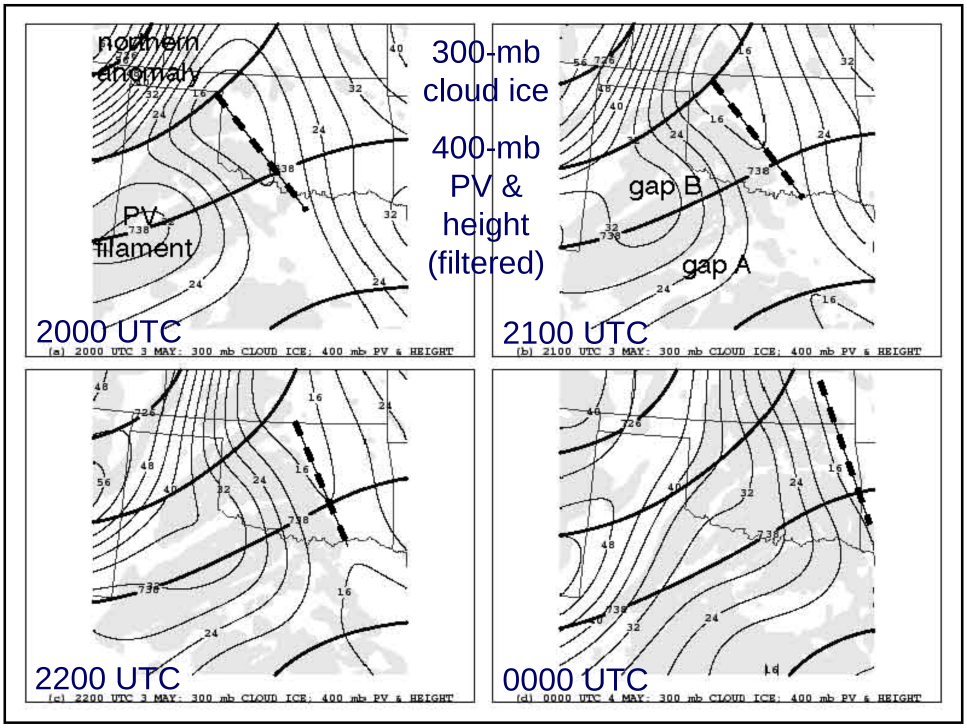
2210 UTC

2230 UTC



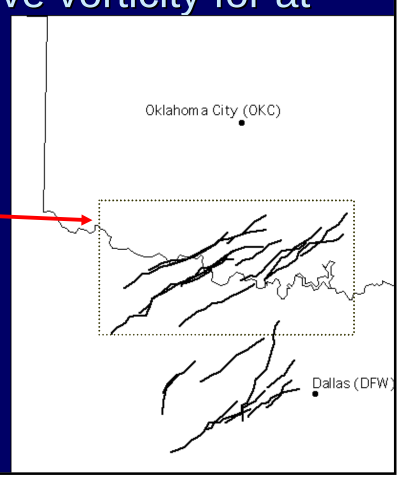
2250 UTC

2310 UTC



Modeled Storms as Supercells

- Identify updrafts(>5 m/s) correlated with vertically coherent relative vorticity for at least 60 minutes
- 22 supercells,
  11 of which are on
  OK–TX border
- Can't address
  tornadogenesis



Observed vs Modeled Supercells

	OBSERVED	MODELED
LIFETIMES (minutes)	120–450 minutes for 10 supercells	60–170 minutes for 11 supercells near OK–TX border
MEDIAN LIFESPAN (minutes)	203	90
SIMULTANEOUS STORMS	7	5
LONGEST TRACK (km)	250	160

Experiments

CNTL: control simulation

NOPV: PV filament removed from initial conds.

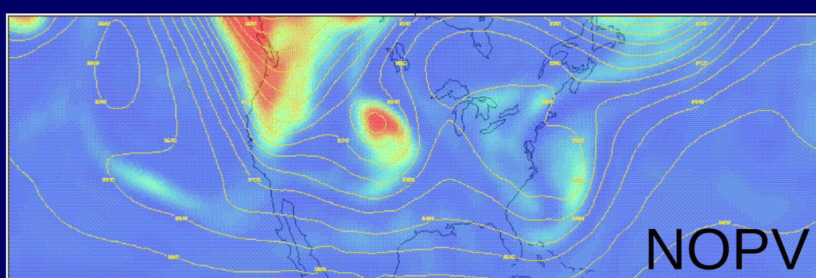
2XPV: PV filament doubled in initial conds.

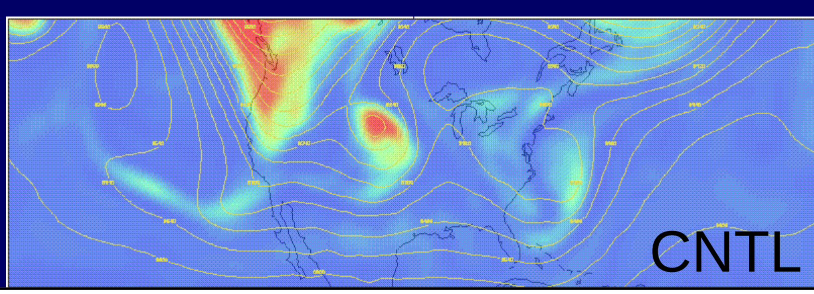
NOCR: cloud-radiative effects turned off

PV-Surgery Methodology

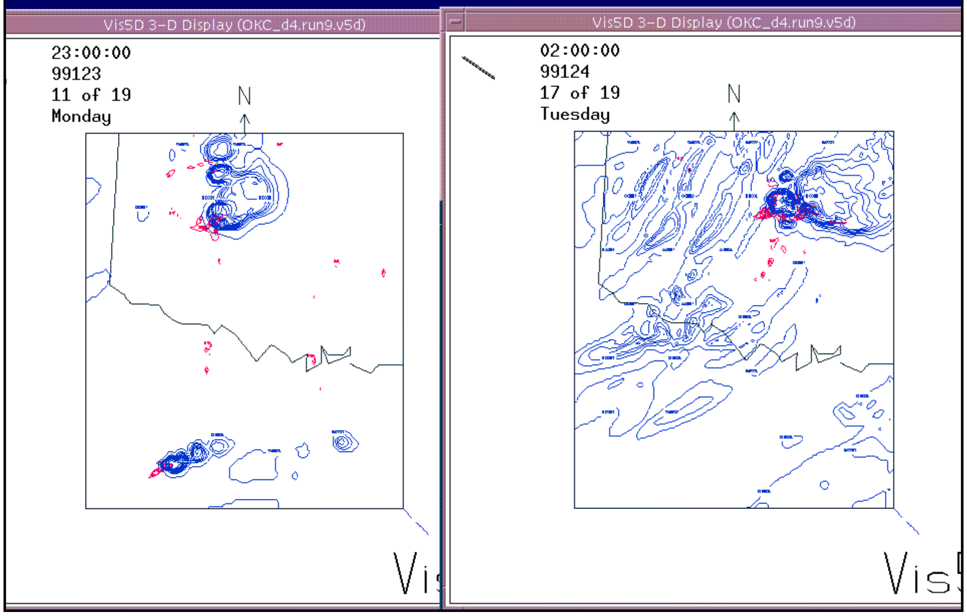
- Compute mean and anomaly PV from 0000 UTC 3 May to 0300 UTC 4 May.
- Isolate PV filament from PV-anomaly field at 0000 UTC 3 May.
- Use PV inversion to calculate the induced flow (wind, temperature, and height) associated with the PV filament (Romero 2001; Davis and Emanuel 1991)
- Remove PV filament, restart MM5 without the filament in the initial conditions

Initial Conditions

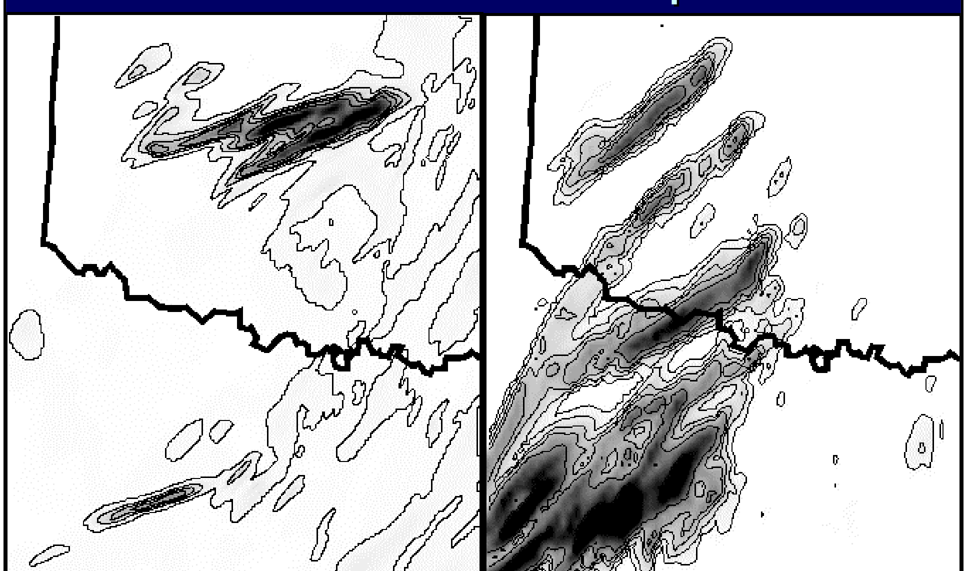




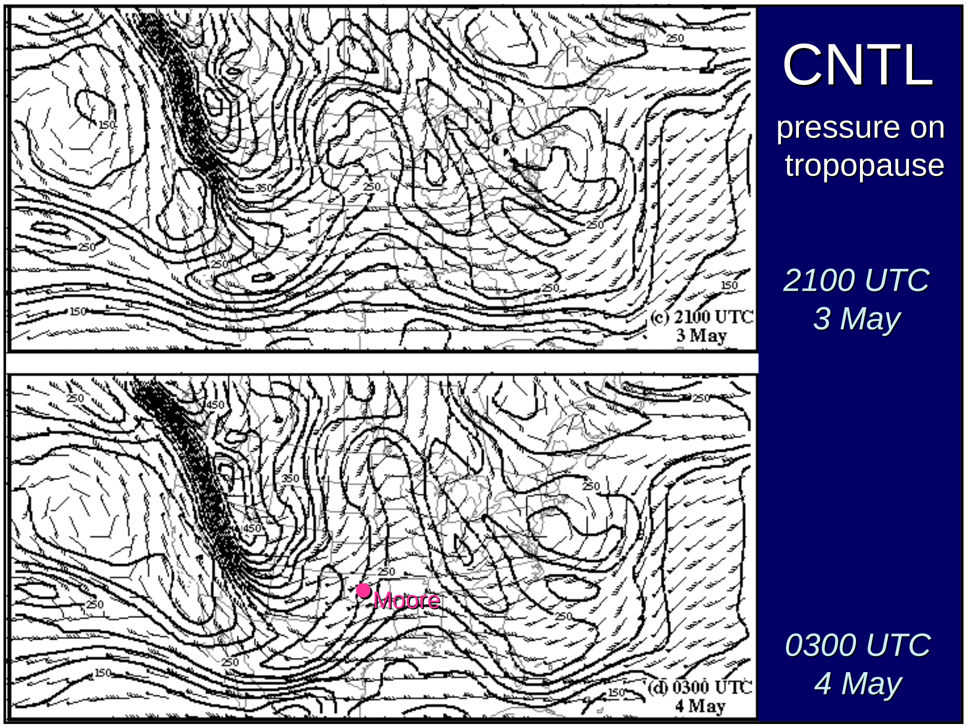
NOPV

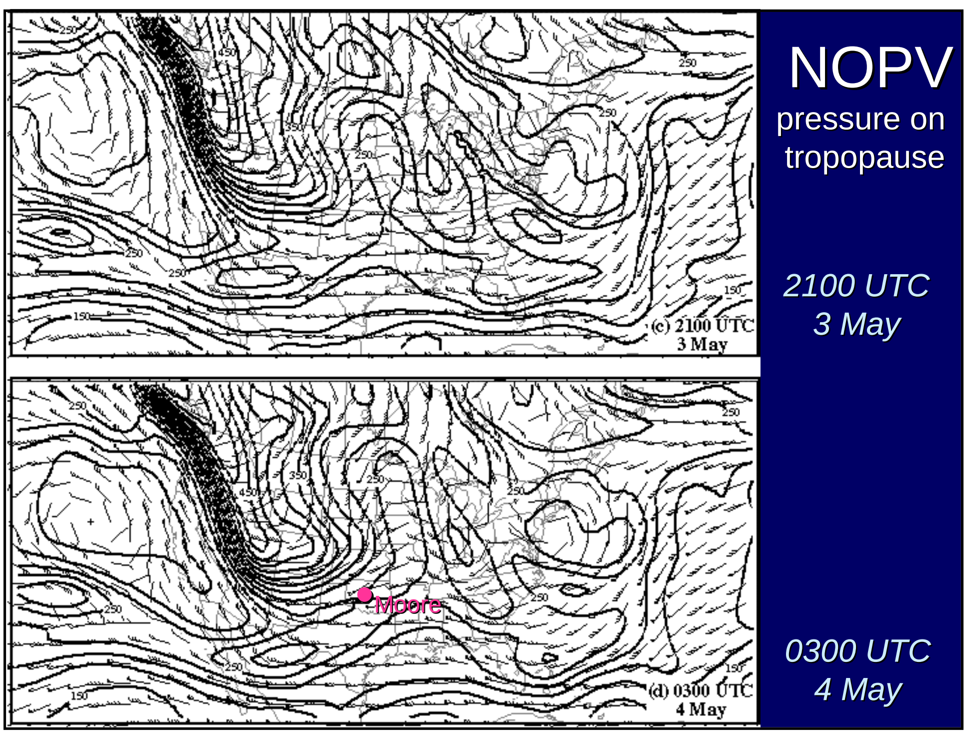


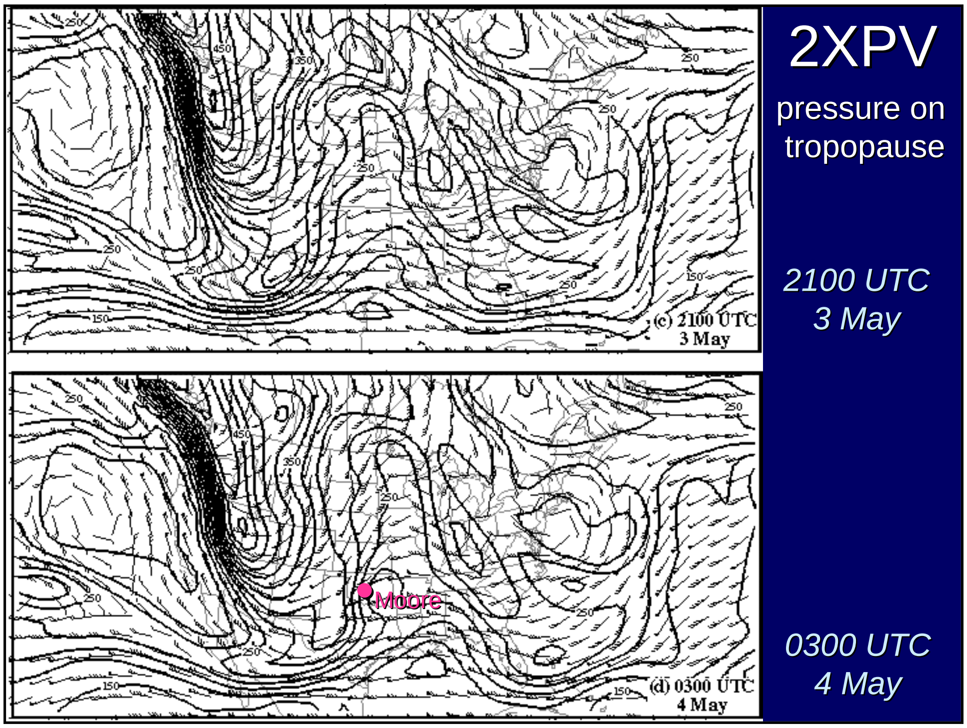
NOPV vs 2XPV Precipitation

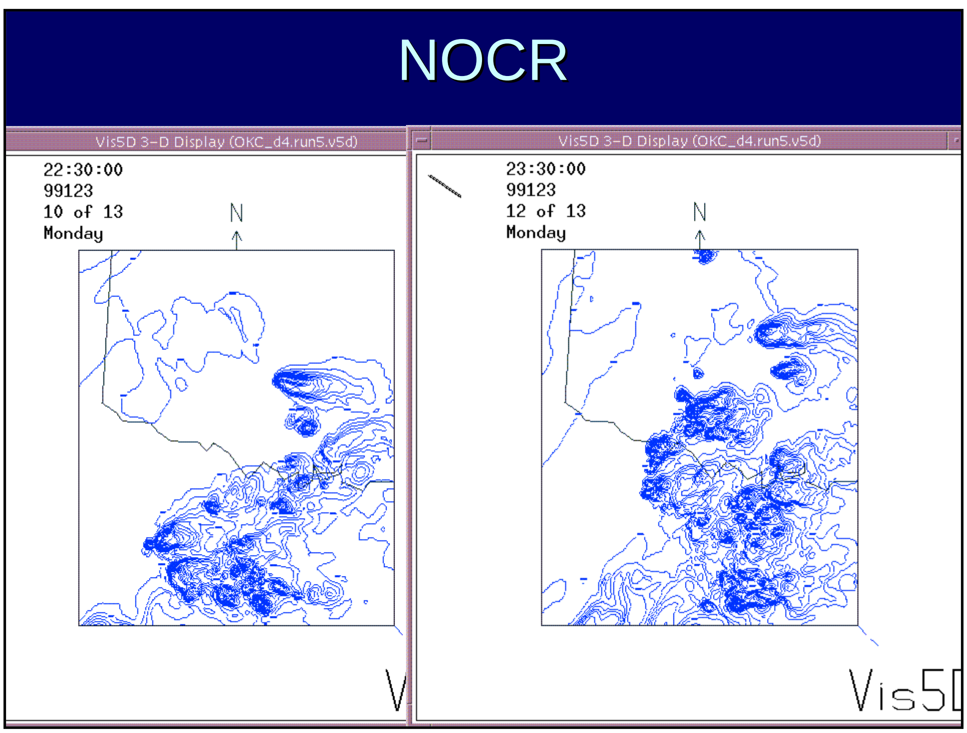


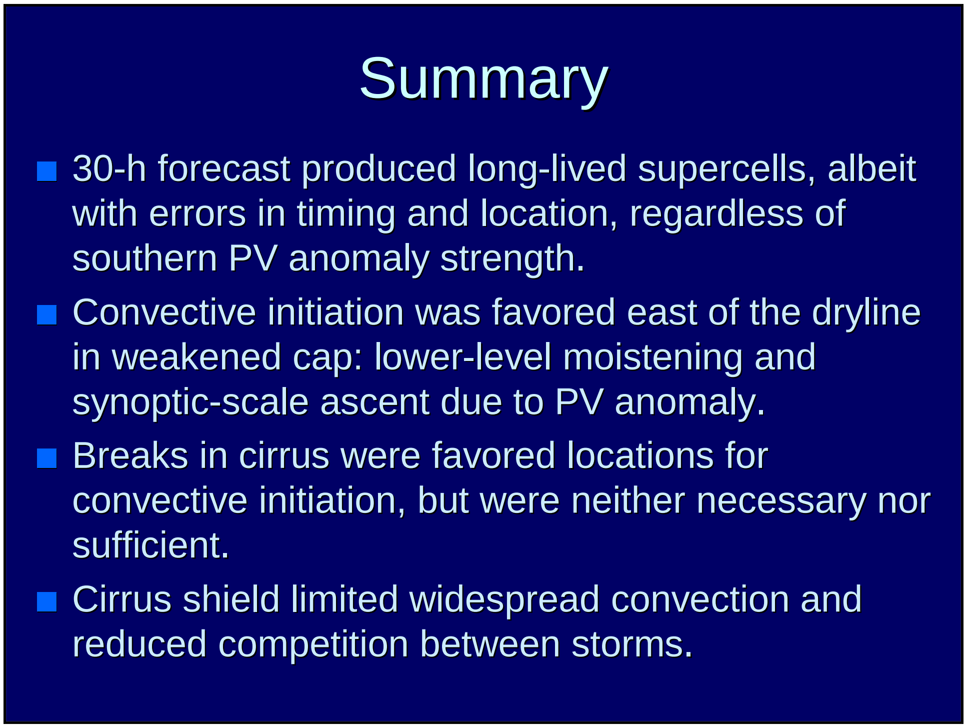
accumulated precipitation: 1800 UTC 3 May to 0300 UTC 4 May
1,5,10,15,25,50,100 mm


CNTL
pressure on tropopause
2100 UTC 3 May
(c) 2100 UTC 3 May
Moore
(d) 0300 UTC 4 May
0300 UTC 4 May


NOPV
pressure on tropopause
2100 UTC 3 May
(c) 2100 UTC 3 May
Moore
(d) 0300 UTC 4 May
0300 UTC 4 May


2XPV
pressure on tropopause
2100 UTC 3 May
0300 UTC 4 May
(c) 2100 UTC 3 May
(d) 0300 UTC 4 May
Moore


NOCR
Vis5D 3-D Display (OKC_d4.run5.v5d)
22:30:00
99123
10 of 13
Monday
N
Vis5D 3-D Display (OKC_d4.run5.v5d)
23:30:00
99123
12 of 13
Monday
N


Summary
30-h forecast produced long-lived supercells, albeit with errors in timing and location, regardless of southern PV anomaly strength.
Convective initiation was favored east of the dryline in weakened cap: lower-level moistening and synoptic-scale ascent due to PV anomaly.
Breaks in cirrus were favored locations for convective initiation, but were neither necessary nor sufficient.
Cirrus shield limited widespread convection and reduced competition between storms.