Weather and Climate

Jim Keller & Paul Belanger

Classroom assistant: Fritz Ihrig

Week 6: February 19th , 2019

Announcements

- **Fritz Ihrig; classroom assistant, liaison to OLLI:**
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- **Paul Belanger:**
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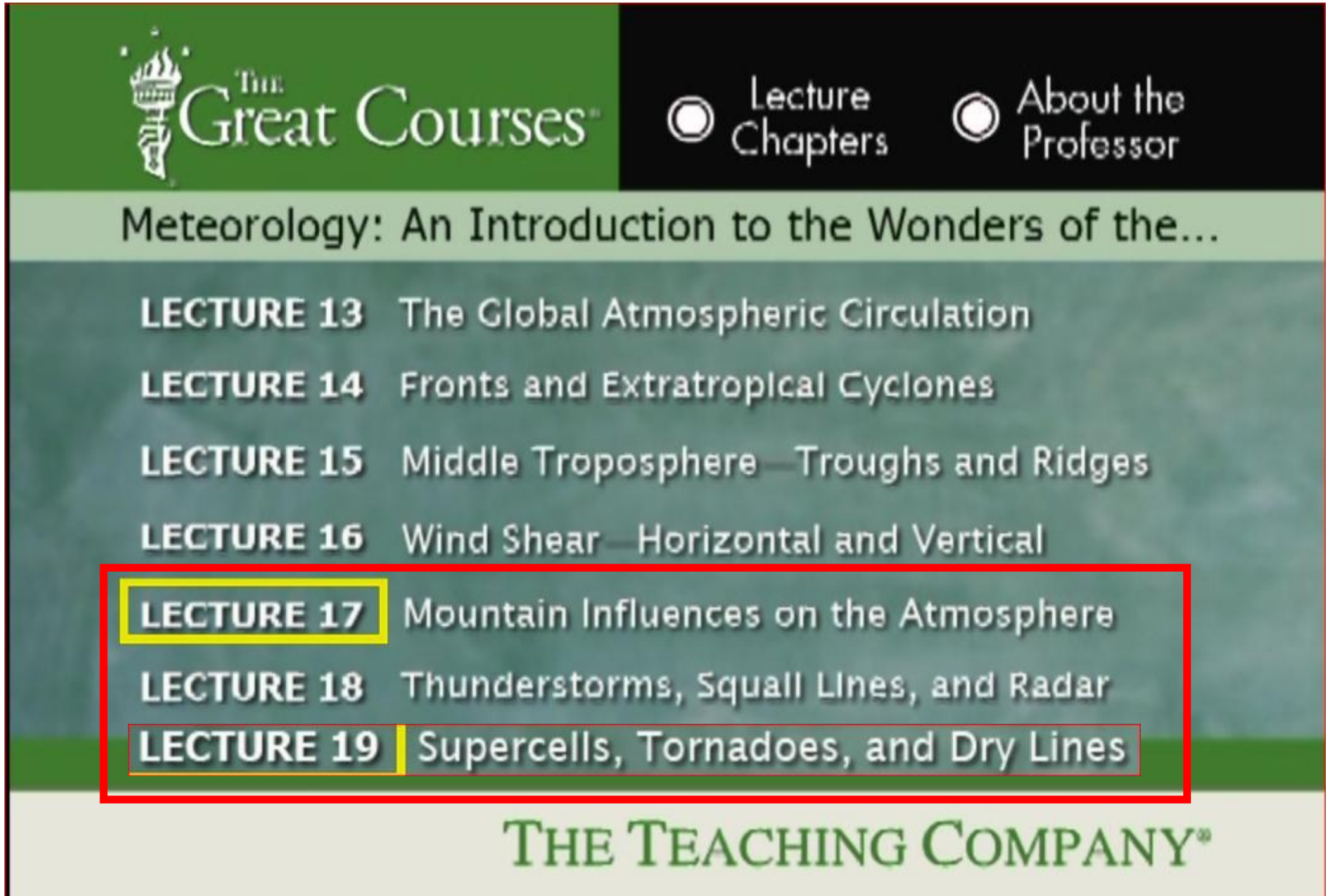
The Great Courses
Lecture Chapters
About the Professor
Meteorology: An Introduction to the Wonders of the...
LECTURE 13 The Global Atmospheric Circulation
LECTURE 14 Fronts and Extratropical Cyclones
LECTURE 15 Middle Troposphere—Troughs and Ridges
LECTURE 16 Wind Shear—Horizontal and Vertical
LECTURE 17 Mountain Influences on the Atmosphere
LECTURE 18 Thunderstorms, Squall Lines, and Radar
LECTURE 19 Supercells, Tornadoes, and Dry Lines
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METEOROLOGY

An Introduction to the Wonders of the Weather

Lecture 17

Mountain Influences on the Atmosphere

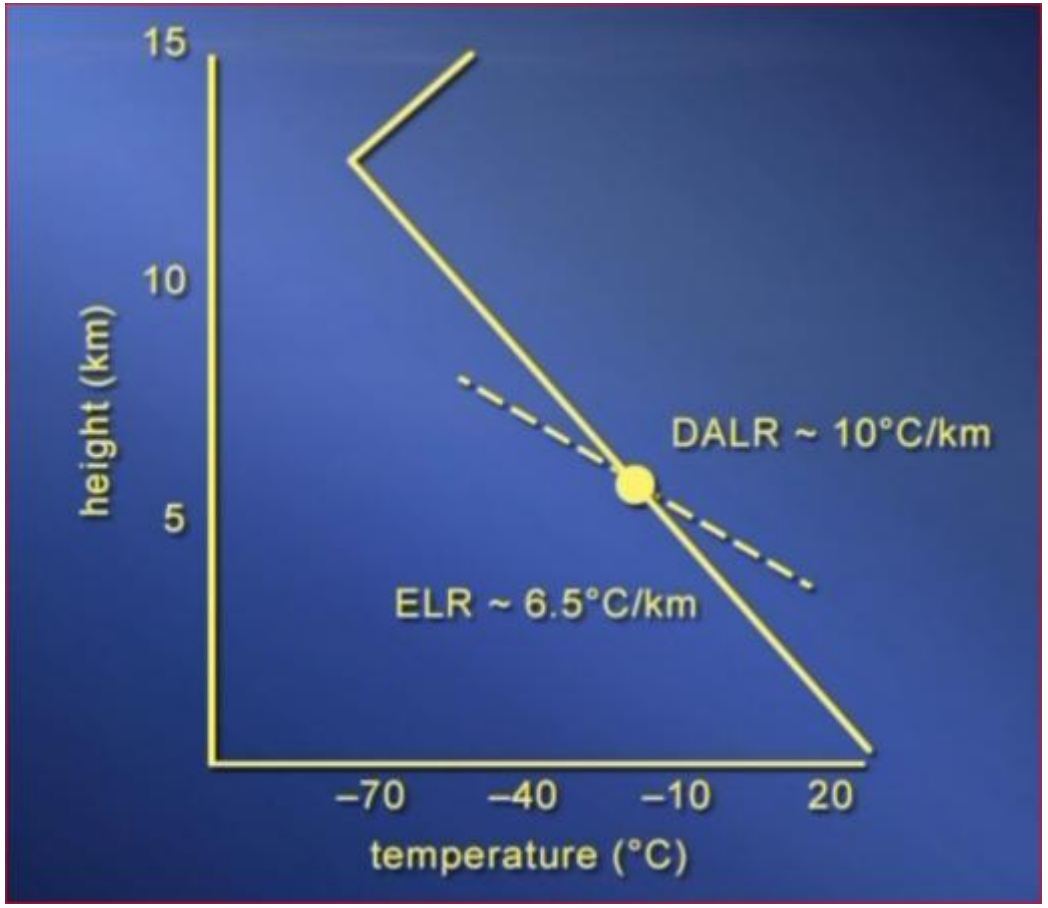
This lecture is about the influence mountains have on the weather

Review earlier

- Hemispheric circulation with a complex 3 cells system complicated by land, oceans, irregular land surface:
  - ascent at 60 degrees and at the equator,
  - descent 30 degrees latitude and the poles;
  - Hadley, Ferrel and polar
- Prevailing Winds
  - Westerlies mid-latitudes
  - Easterlies at the poles
  - And NE or SE at the equator/tropics
- Air Masses
  - Maritime/Oceanic or continental in type
  - Polar or tropical in Origin
  - 4 Air Mass types:
    - cP = continental Polar
    - cT = continental Tropical
    - mP = maritime Polar
    - mT = maritime Tropical
- Fronts – where air masses of different densities meet

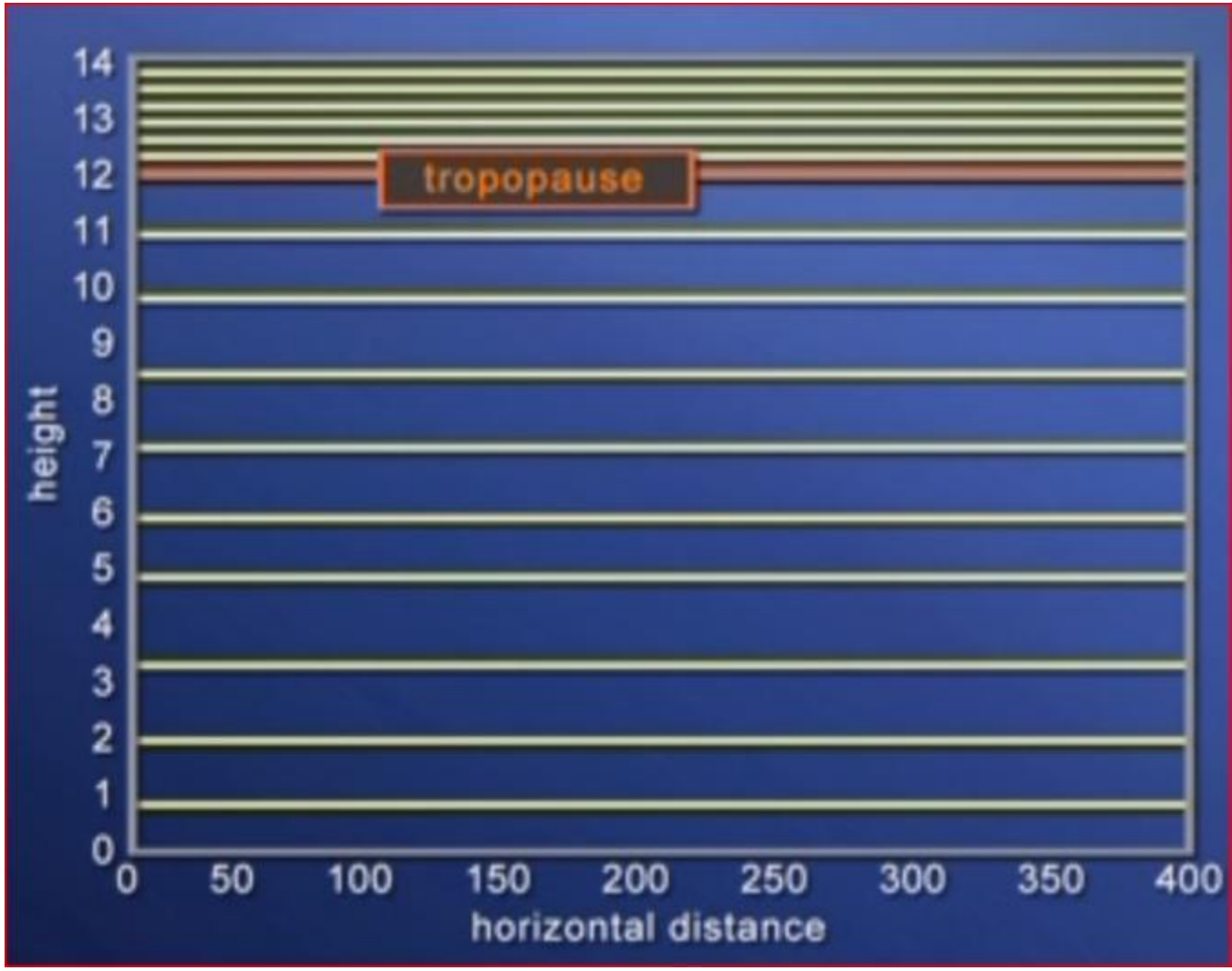
Discuss

- Surface gravity waves
- Mountains are internal gravity waves
  - Stationary
  - Dynamic
  - Horizontally stable, but not vertically stable
- ELR – Environmental lapse rate ~6.5 C/km
- DALR – Dry adiabatic lapse rate of 10C/km
- Stratosphere more stable than Troposphere



Atmospheric Stability

- Isentropes: lines of constant entropy
- Lines indicate degree of stability; the closer the more stable – thus the stratosphere (above the tropopause) is more stable than the troposphere below it
- Mountains and associated waves disrupt that

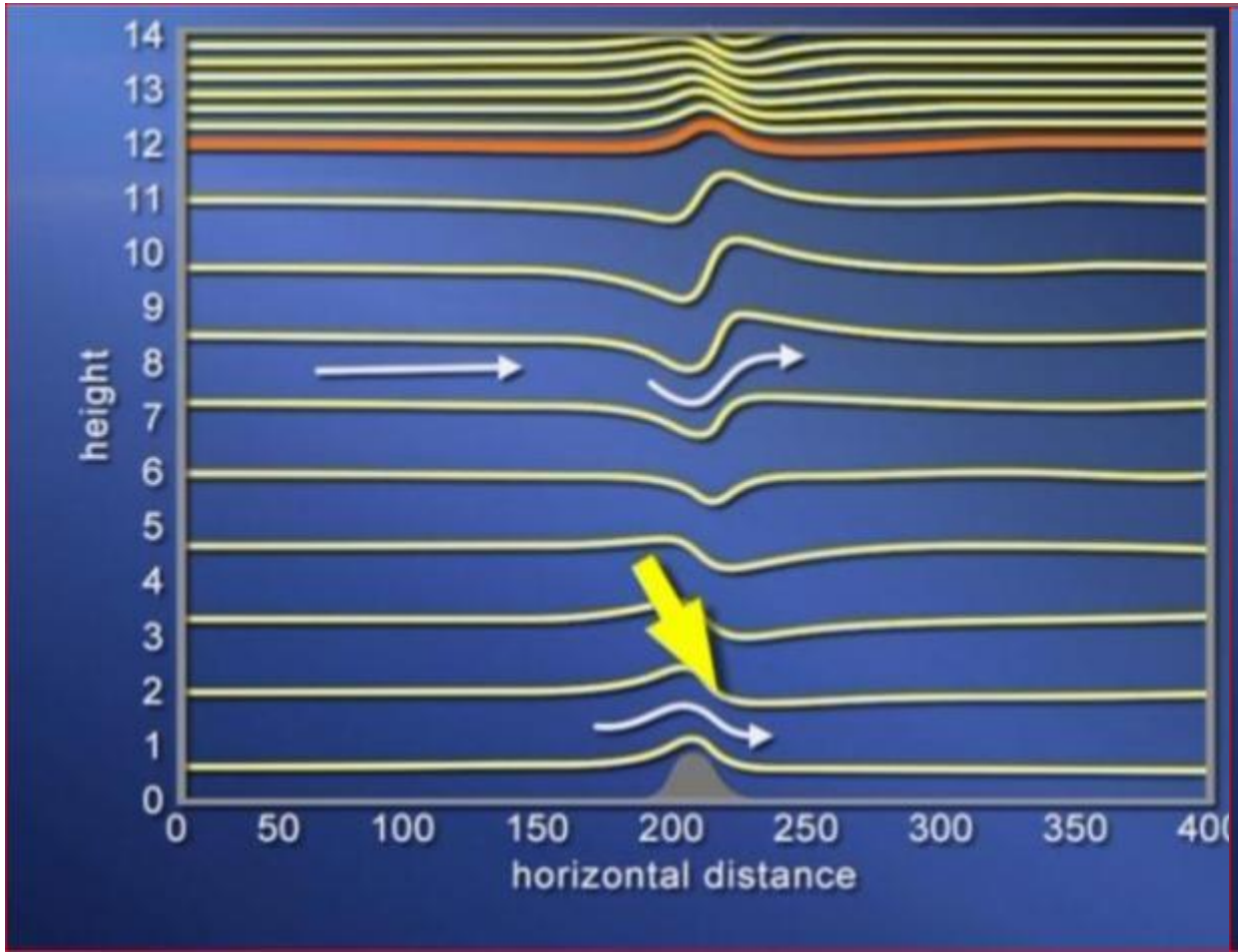


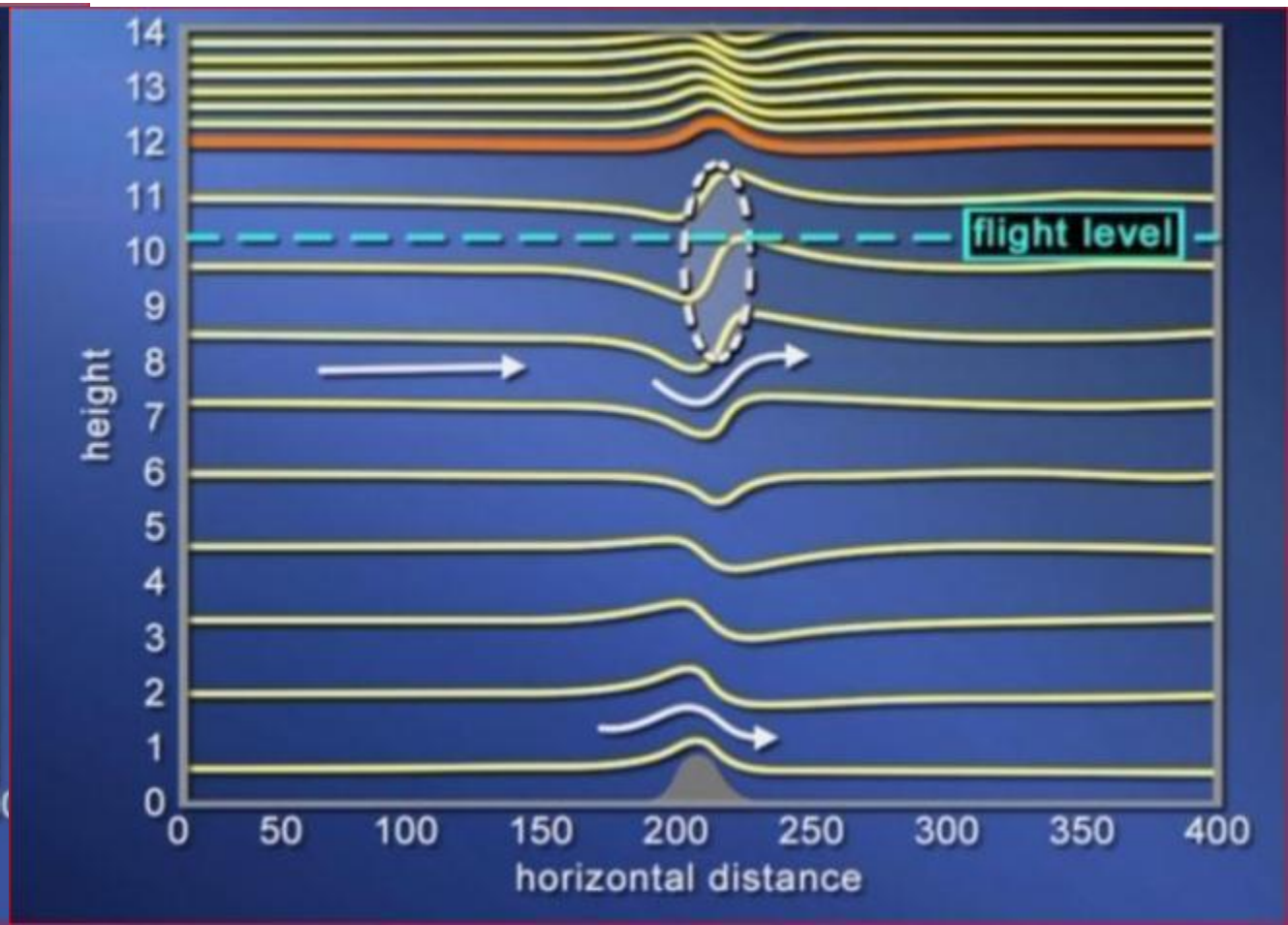
https://en.wikipedia.org/wiki/Isentropic_process

https://en.wikipedia.org/wiki/Isentropic_process

downslope wind storm hydraulic jump

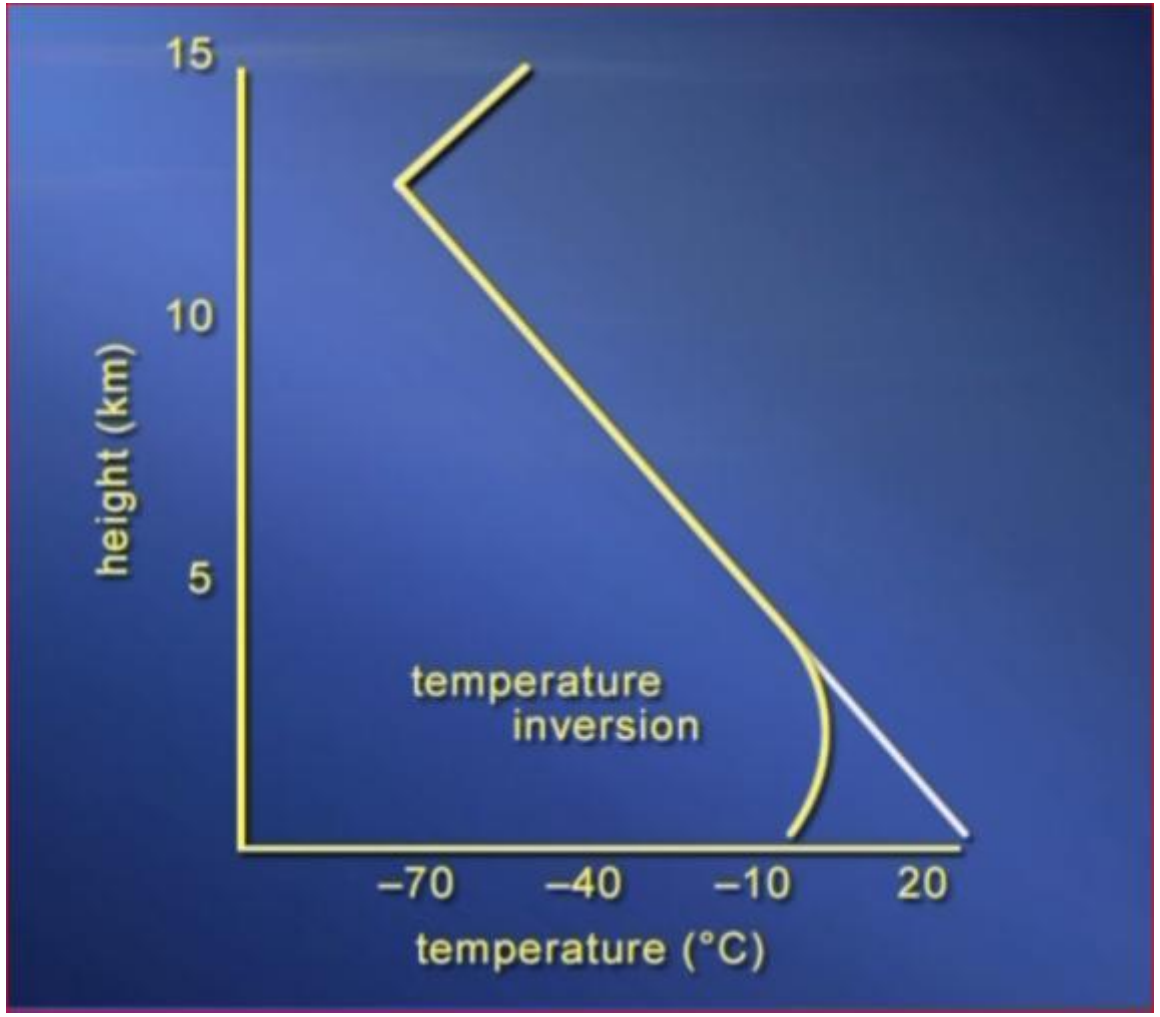
- Air parcels want to come back to the level it started
- Mountain waves – stationary to the round but disrupt the vertical





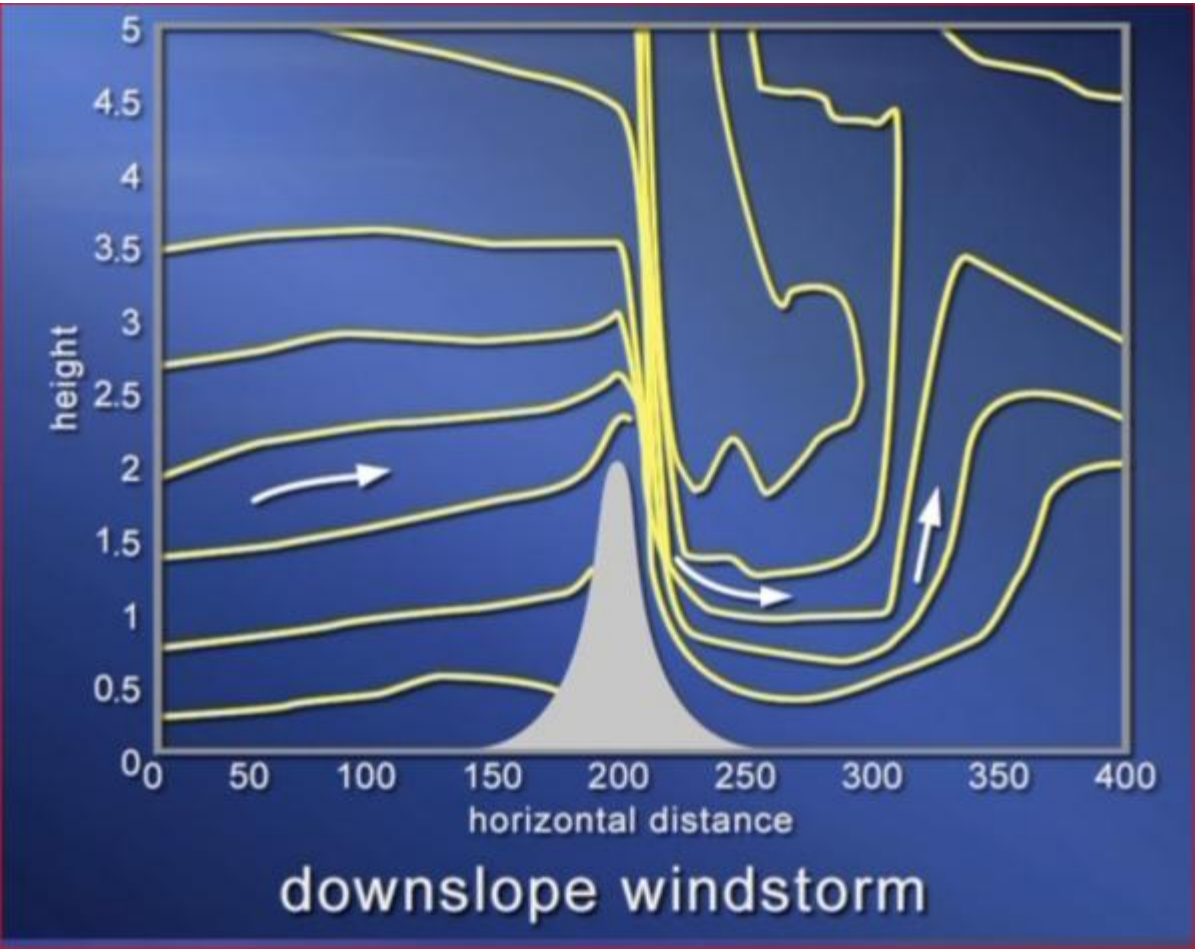
Temperature inversions

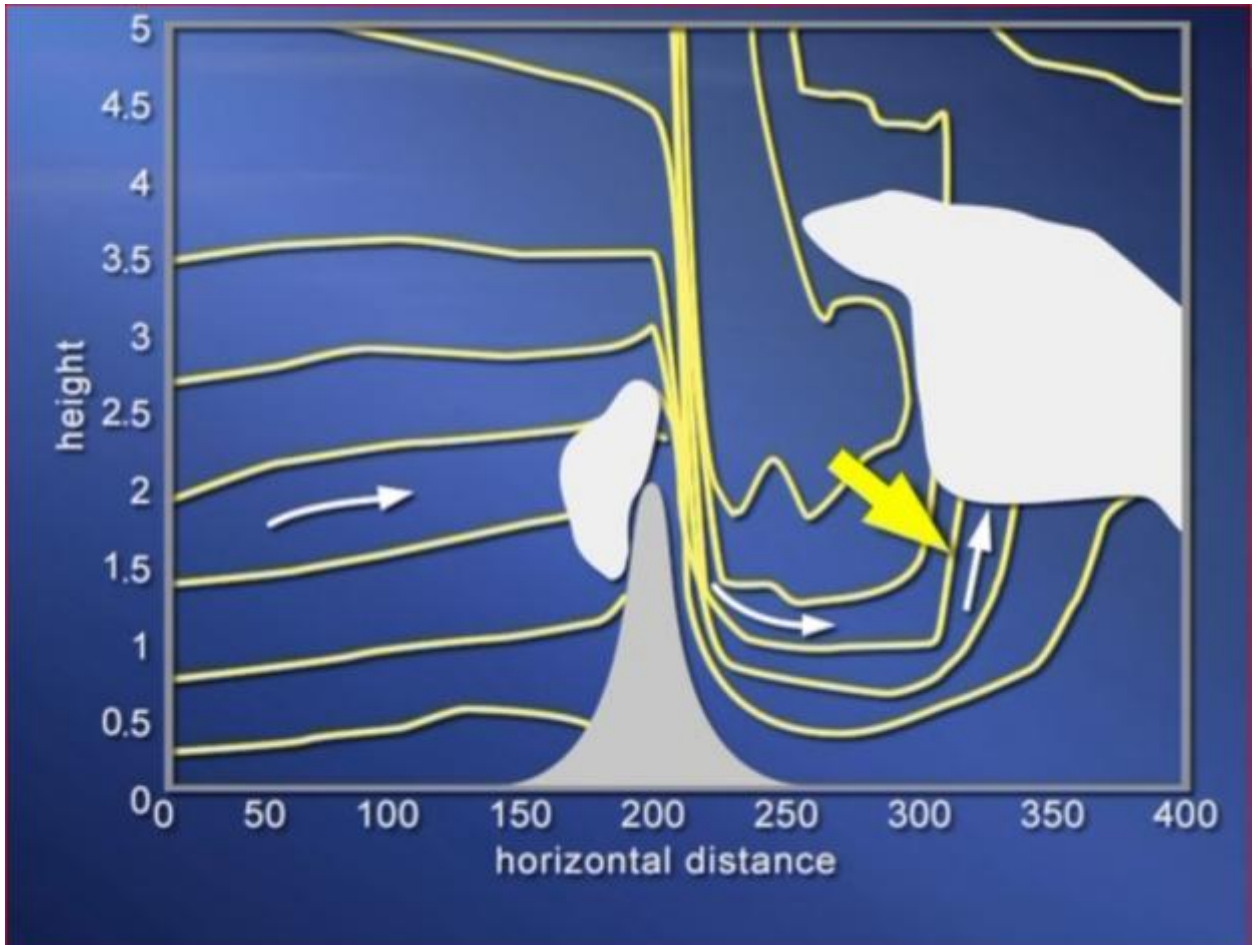
- reasons:
  - Cool below-higher density, warmer above-lower density
  - Cool, dry owing to lack of water vapor in clouds
  - Vertical wind shear etc.
  - Denver's Brown Cloud
- Can prevent disturbances higher up



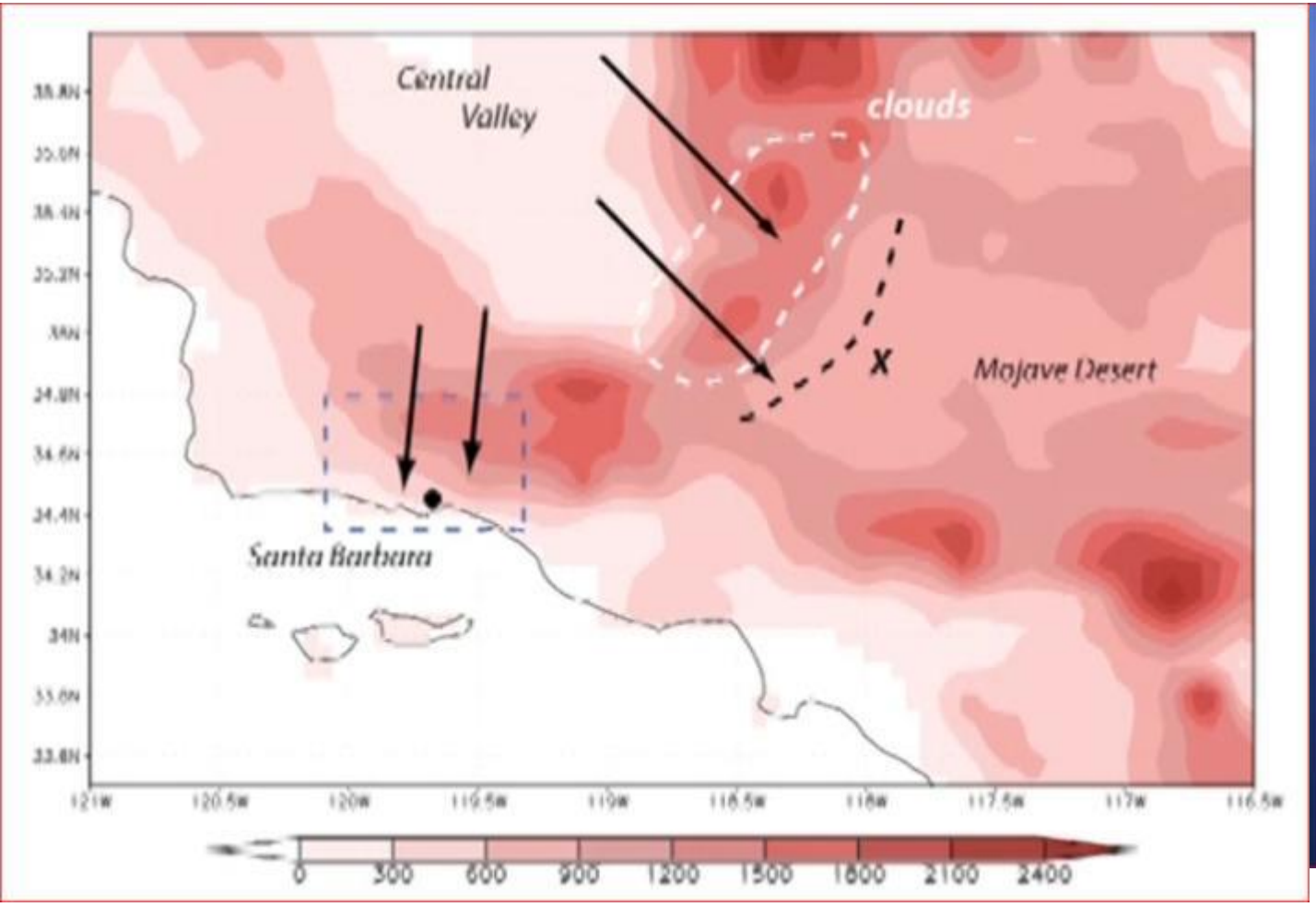
Clouds can form 2 places

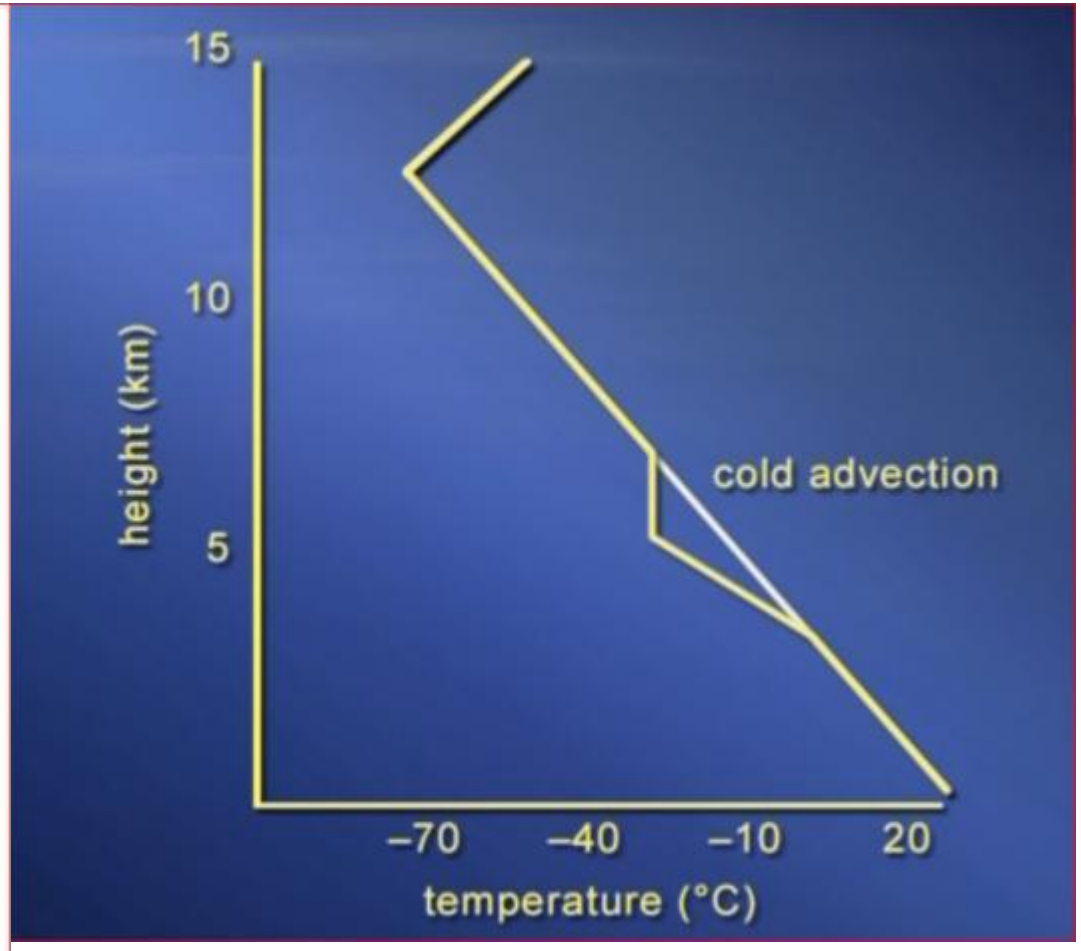
- Very Strong Winds Downslope & Hydraulic Jump farther downwind



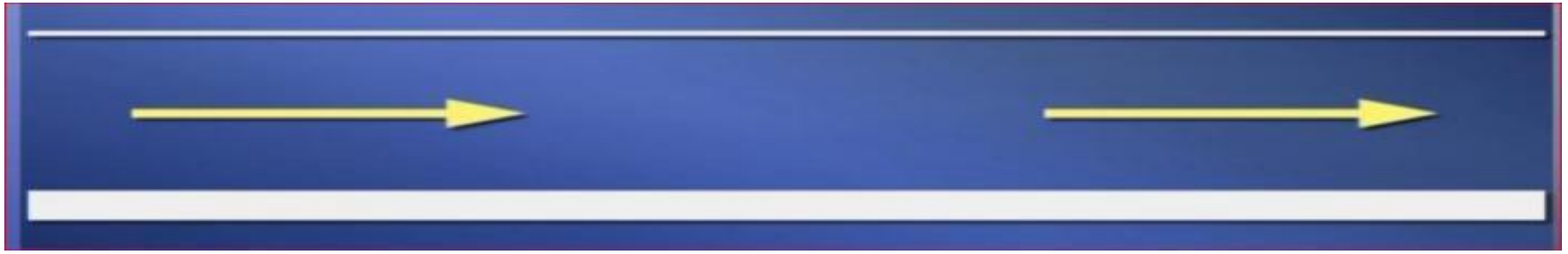


Hydraulic Jump on left, wind from right

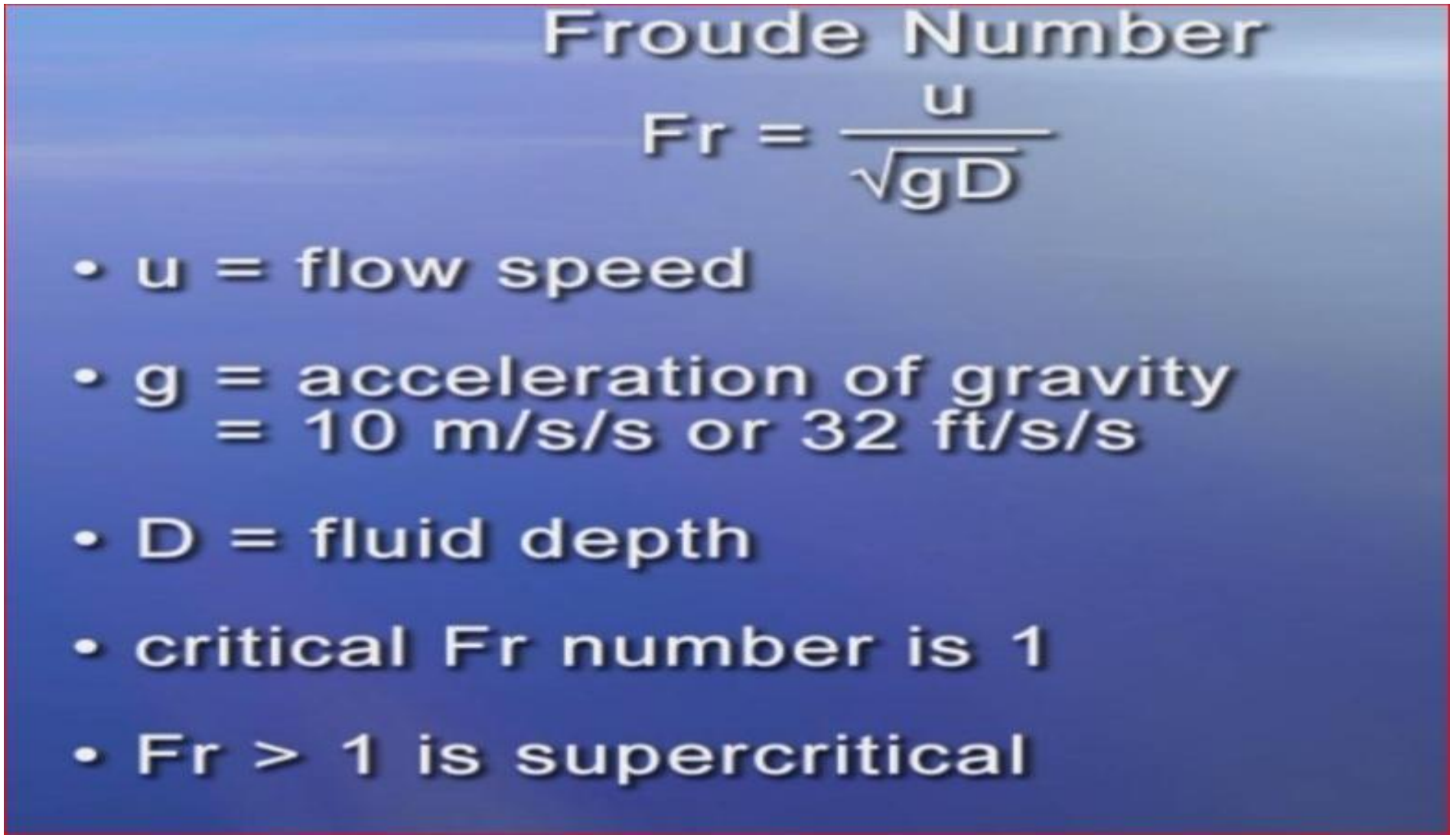

Central
Valley
clouds
X
Mojave Desert
Santa Barbara
121W
120.5W
120W
119.5W
119W
118.5W
118W
117.5W
117W
116.5W
0
300
600
900
1200
1500
1800
2100
2400


15
10
5
height (km)
cold advection
–70
–40
–10
20
temperature (°C)

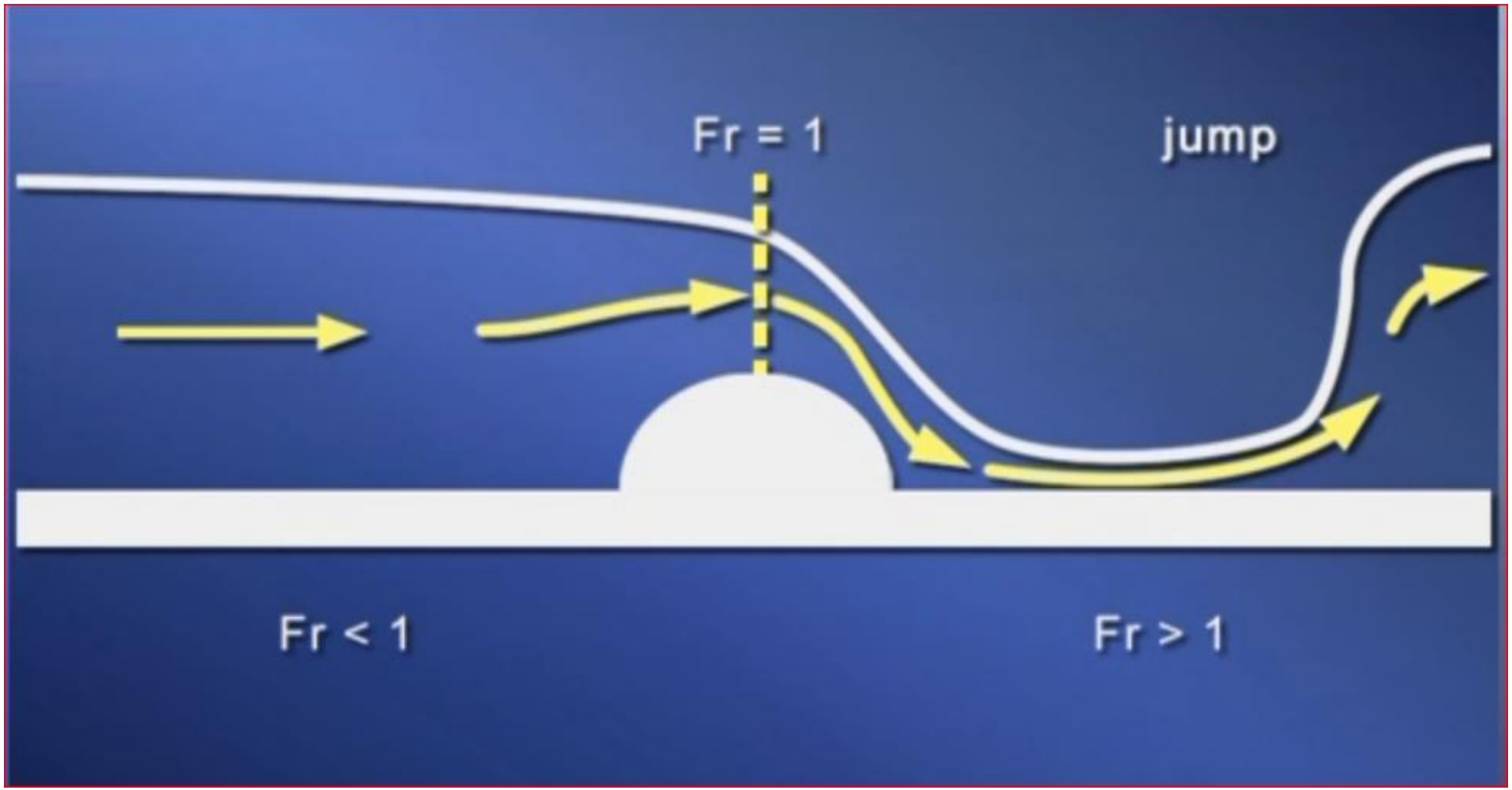
Flow Regimes

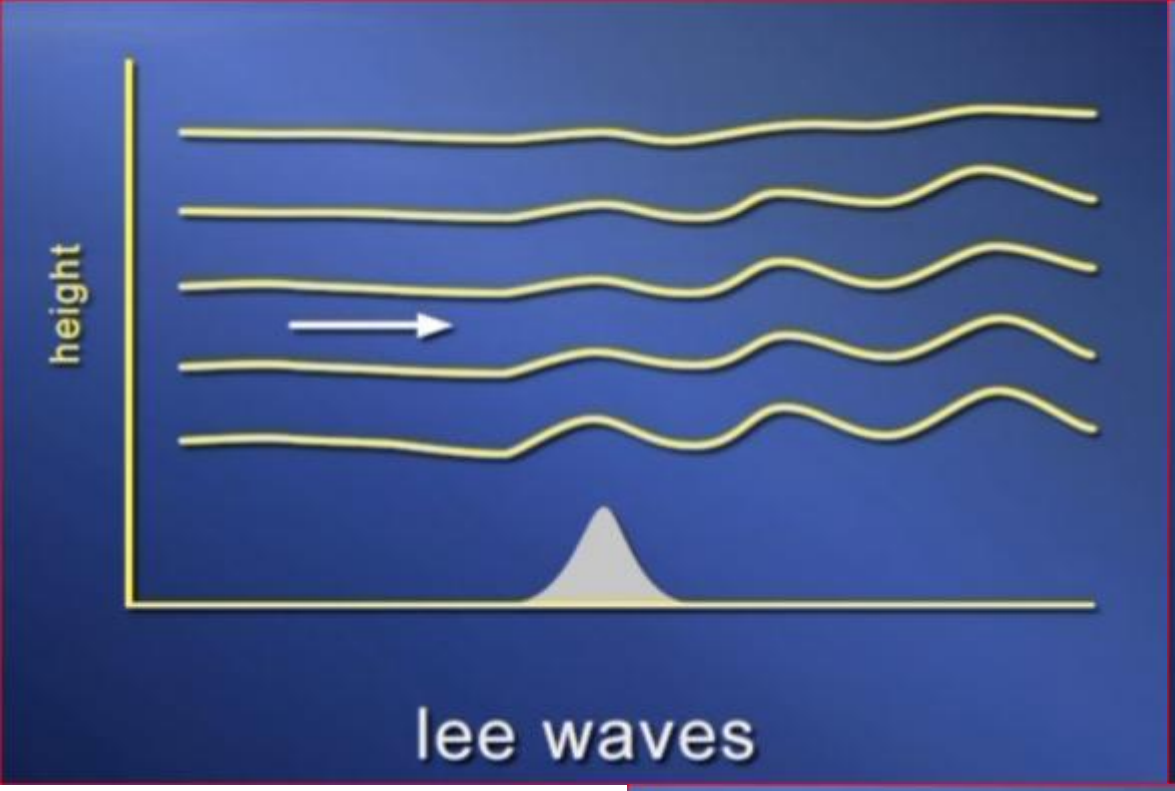


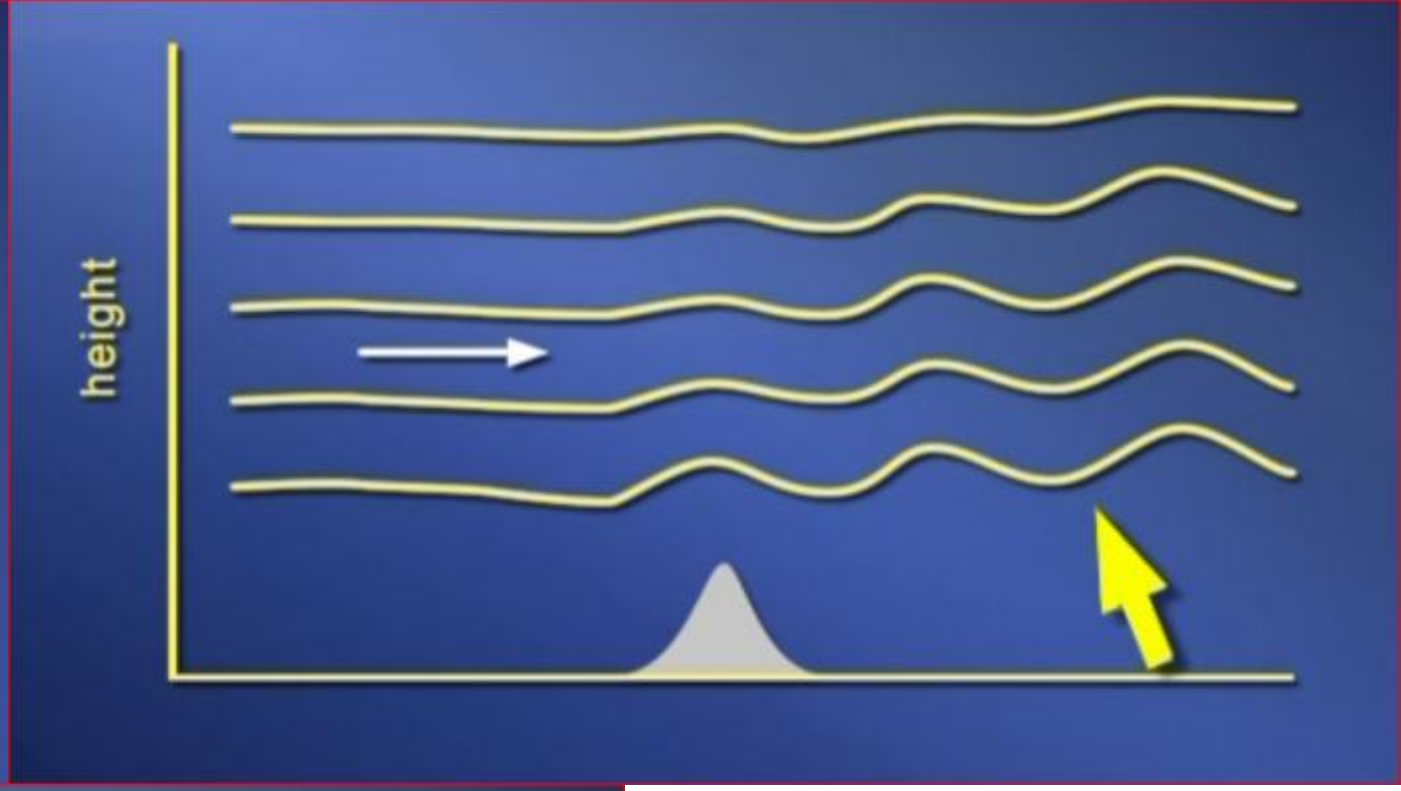
Froude Number & Flow Regimes

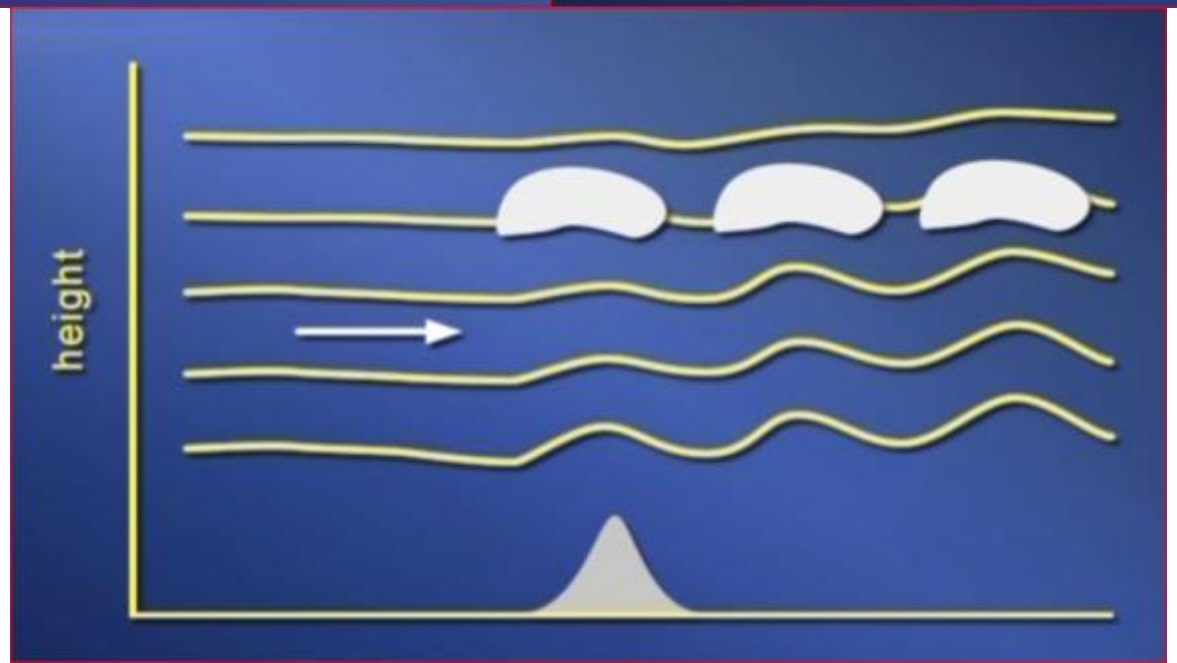


Froud Number & Hydraulic Jump

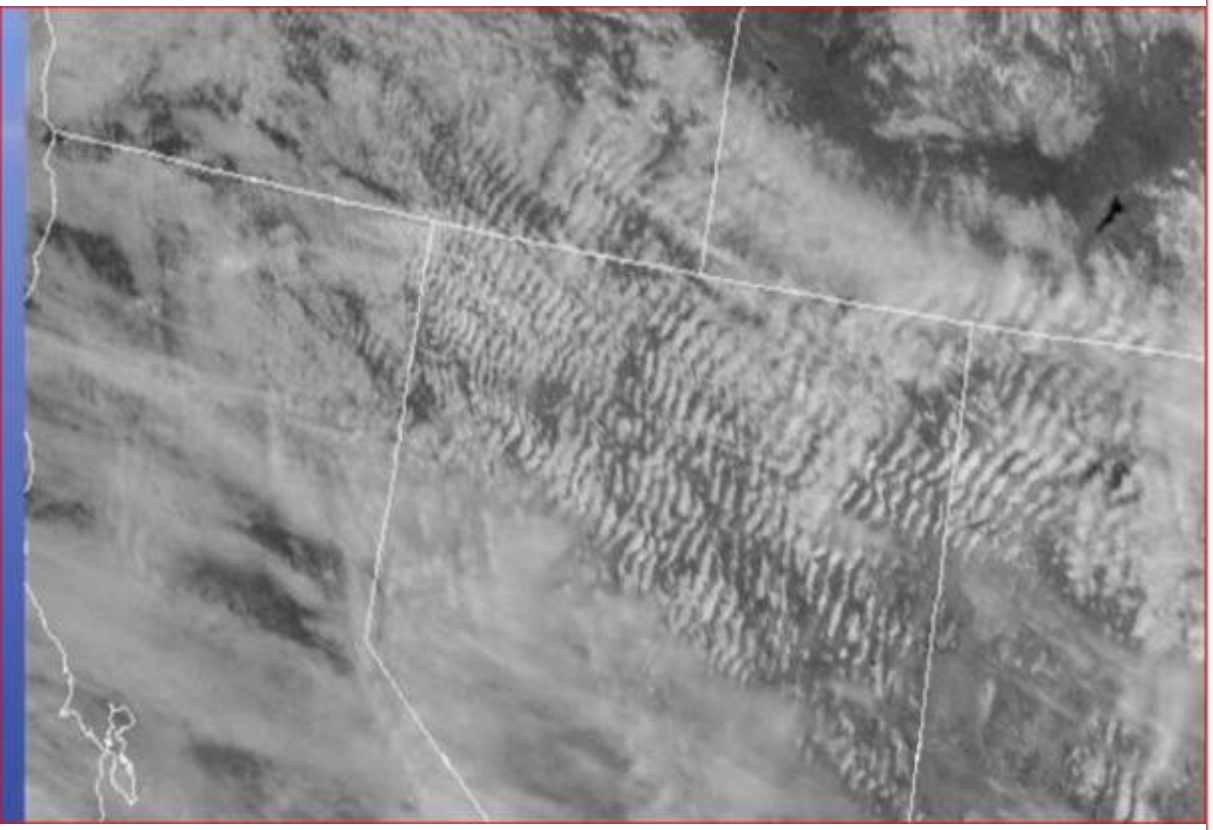


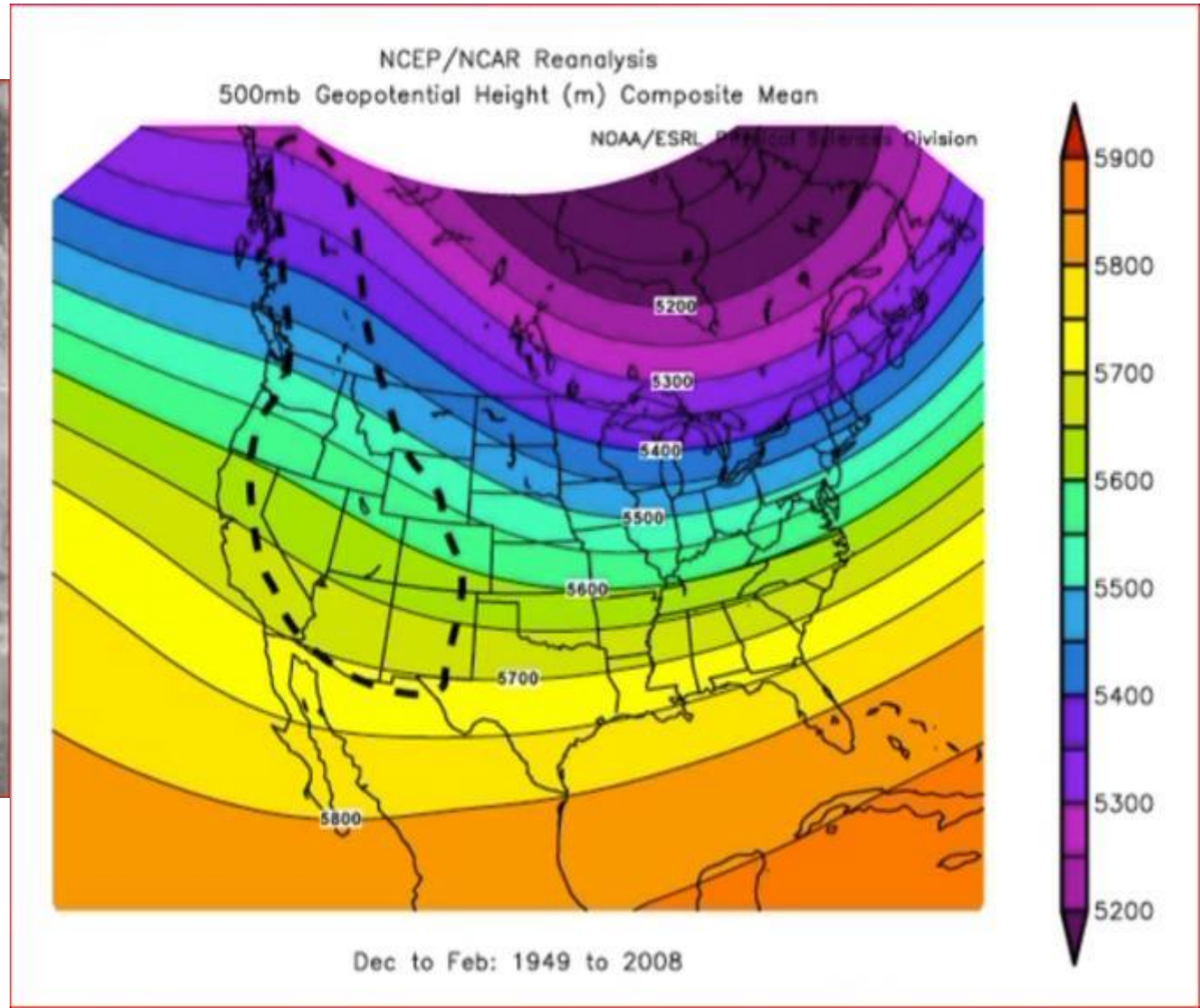

height
lee waves


height


height

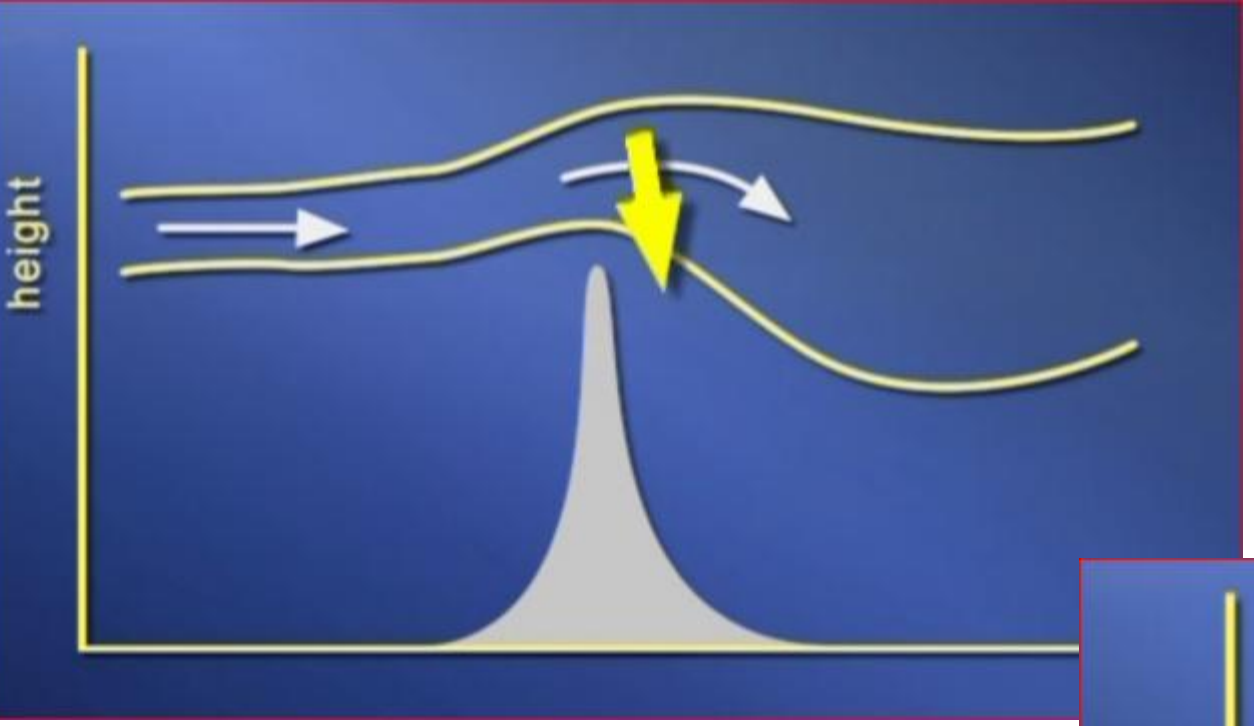
Lee Waves

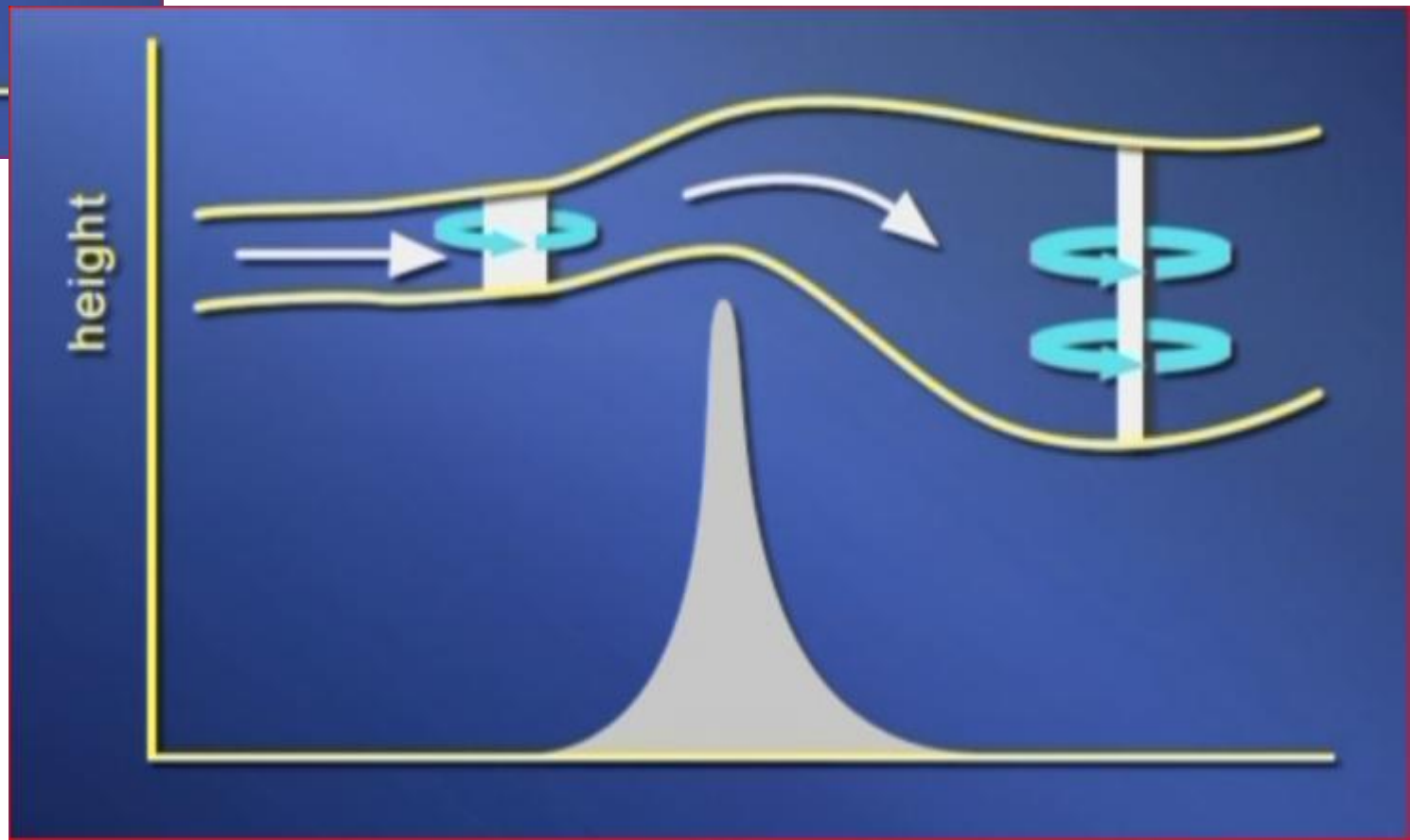



NCEP/NCAR Reanalysis
500mb Geopotential Height (m) Composite Mean
NOAA/ESRL
Division
5200
5300
5400
5500
5600
5700
5800
5900
5800
5700
5600
5500
5400
5300
5200
Dec to Feb: 1949 to 2008

Mountains make troughs; and can make extratropical cyclones

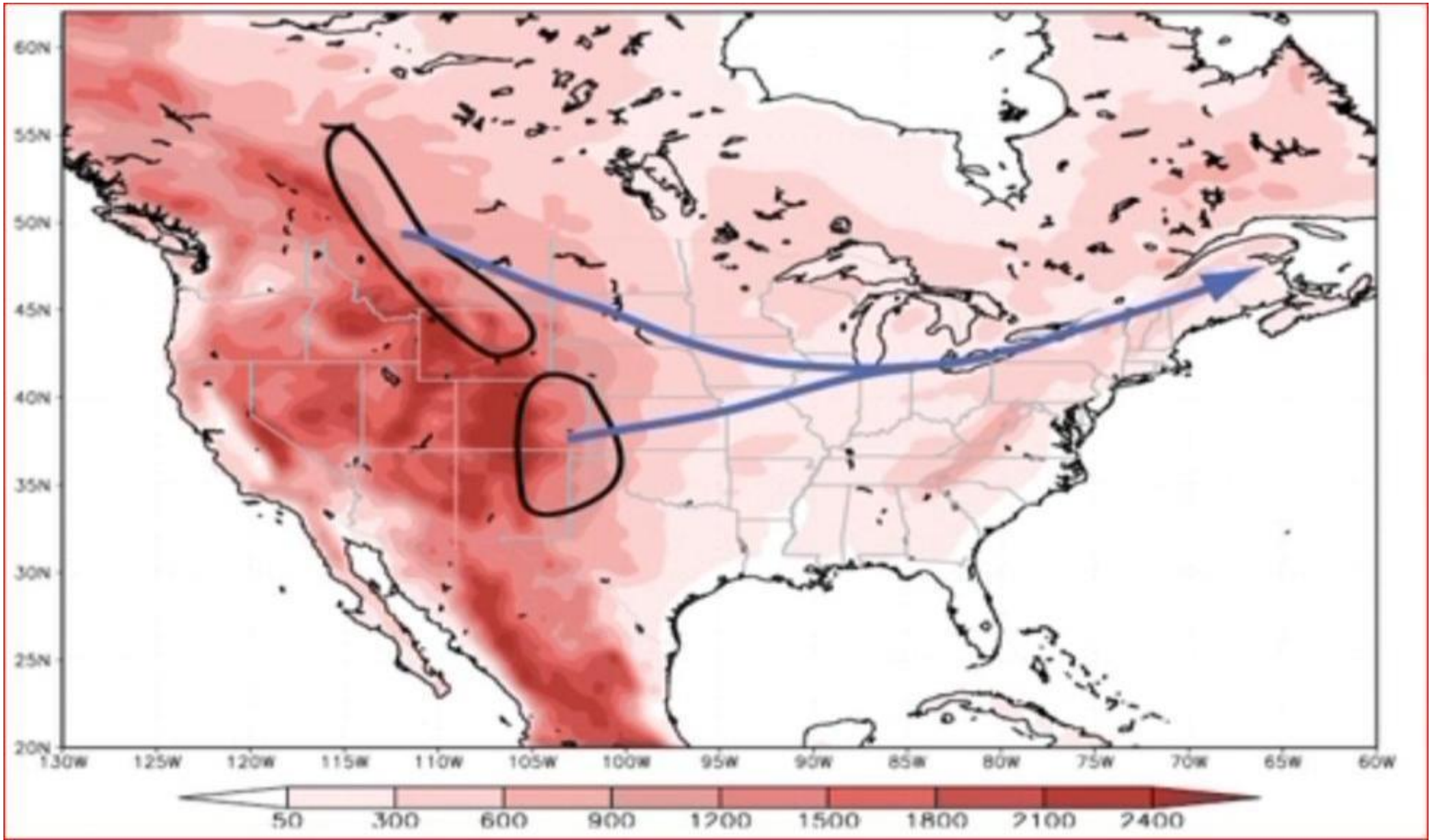
- HORIZONTAL WIND PLUS EARTH'S SPIN CAN CAUSE VERTICAL AXIS SPIN (VORTICITY) IN HORIZONTAL PLANE & FORMATION OF CYCLONES





Earth's spin causes horizontal wind spin which creates low pressure - i.e. a cyclone

Mountain Lee Cyclones



Mountains have a huge role in weather

- Cause air disturbances
- Cause instability
- Propagate up to higher altitudes
- Cause downwind waves, hydraulic jumps and cyclones

METEOROLOGY

An Introduction to the Wonders of the Weather

Lecture 18

Thunderstorms, Squall Lines, and Radar

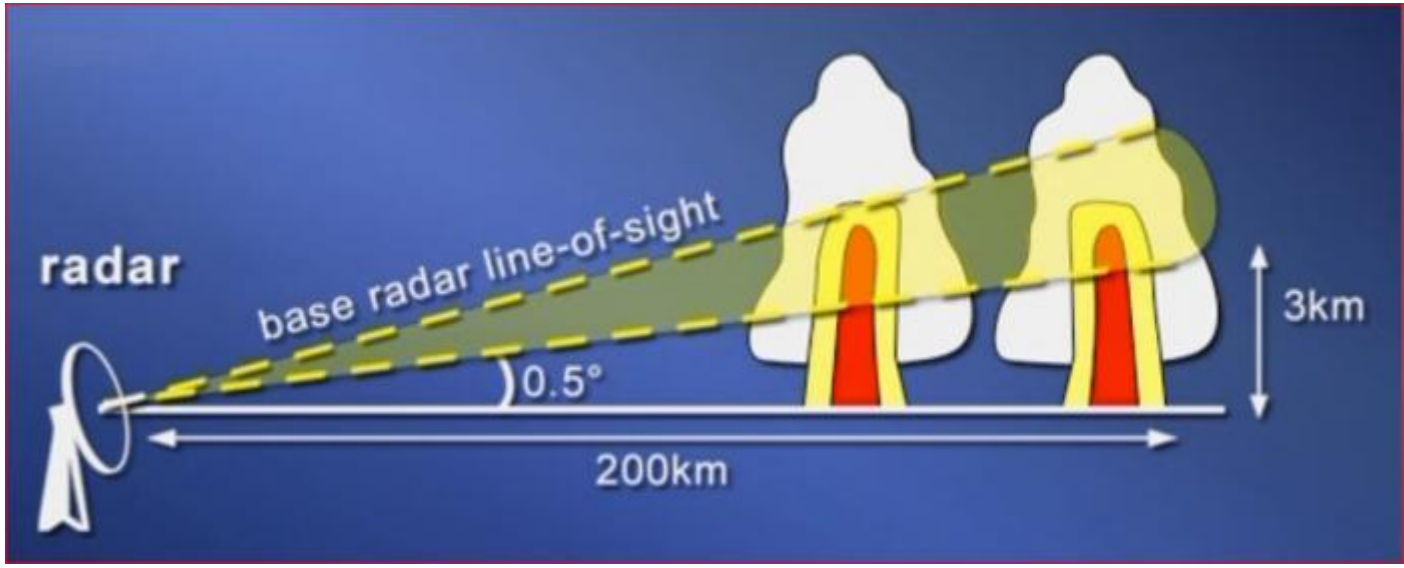
The squall line Thunderstorm

- Often near coastline
- Sources providing forecasts:
  - NWS
  - NCAR
  - Acting weather and other companies providing forecasts
- Some of the URLS we will explore:
  - http://weather.gov/bouThen below that:
    - https://www.weather.gov/bou/weatherstory
  - https://www.weather.gov/
    - and put in Genesee, co
    - detail goes here https://forecast.weather.gov/MapClick.php?textField1=39.69&textField2=-105.27#.XGRIHvZFx3g
  - this site http://weather.rap.ucar.edu/ is very good – many many sub-maps and links/options:
    - NAM model
    - Satellite image
    - MLSP/WINDS
    - http://weather.rap.ucar.edu/model/displayMod.php?var=eta_sfc_mslp&loop=loopall&hours=
    - Precip http://weather.rap.ucar.edu/model/displayMod.php?var=eta_sfc_prcp&loop=loopall&hours=

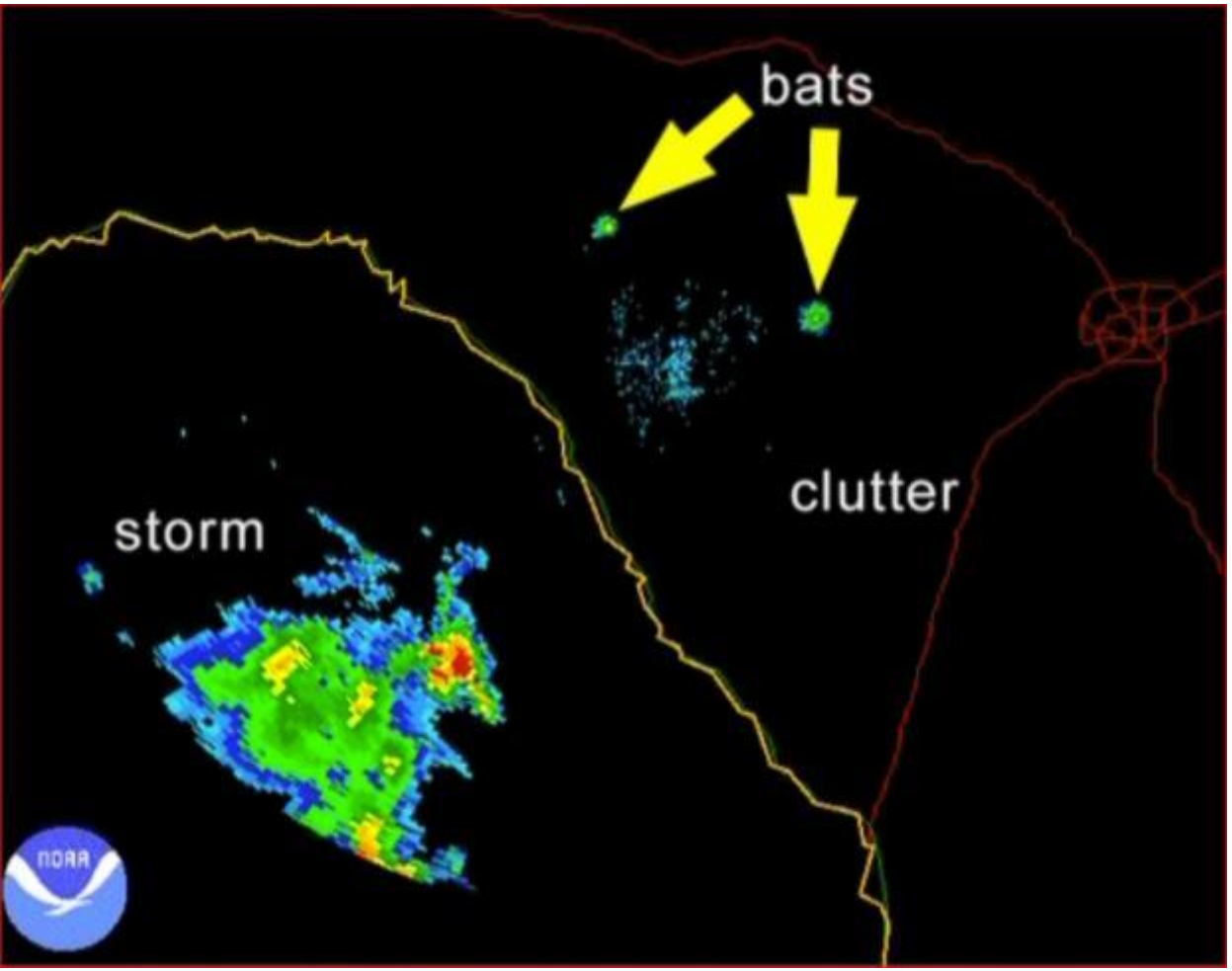
National Weather Service (NWS)- Doppler Radar sites:

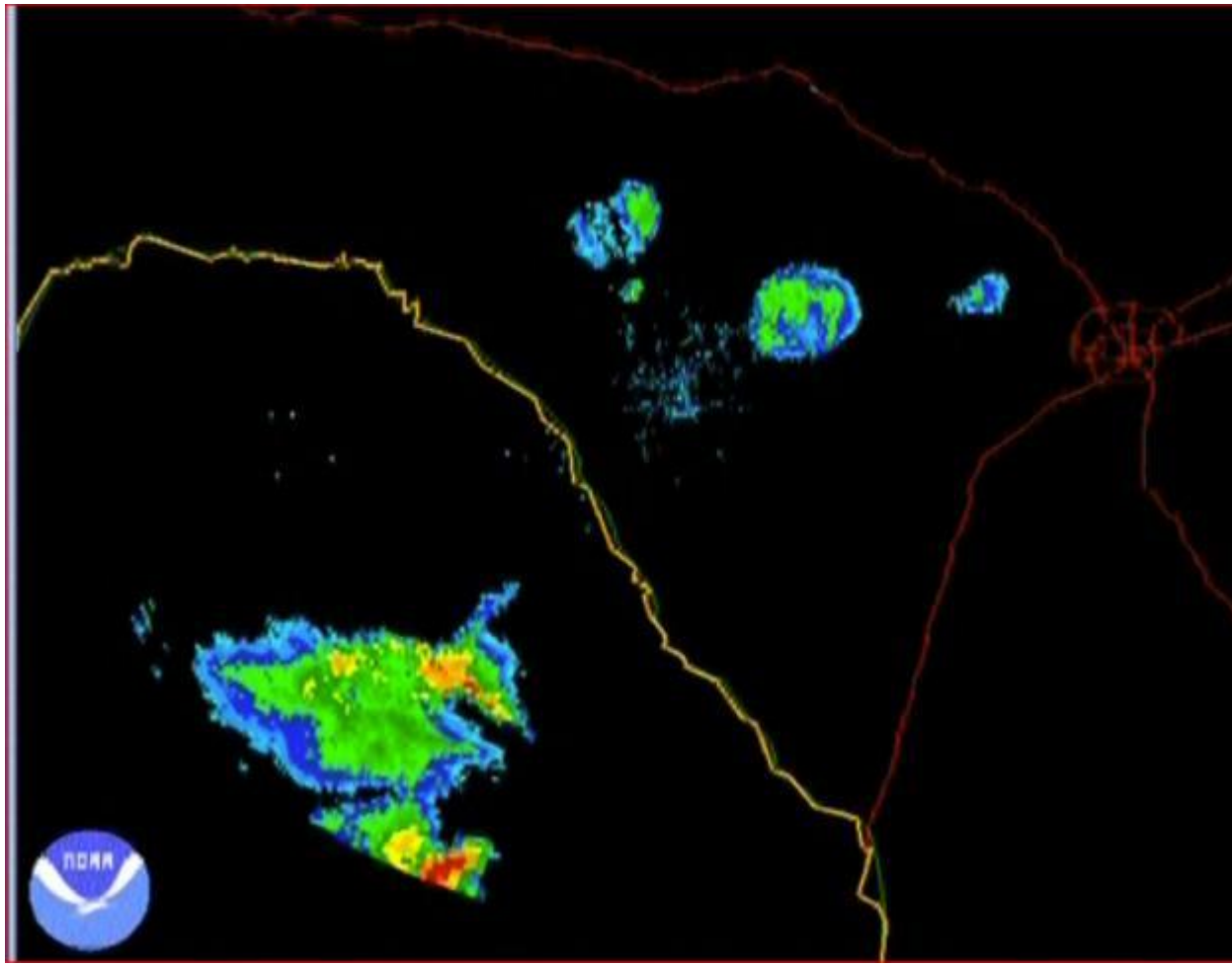
- Real time weather monitoring

- Radar https://en.wikipedia.org/wiki/Radar
  - Doppler = pulse; listens back
  - Different sizes, dependent of frequency, etc.
  - 10cm focus in lecture
  - Decibels dBZ – units of decibels
  - Underestimates ice and snow
  - Hail stones the “brightess”
  - Butterflies, bats seen; ground clutter, etc.



5/9/2009- San Antonio, TX

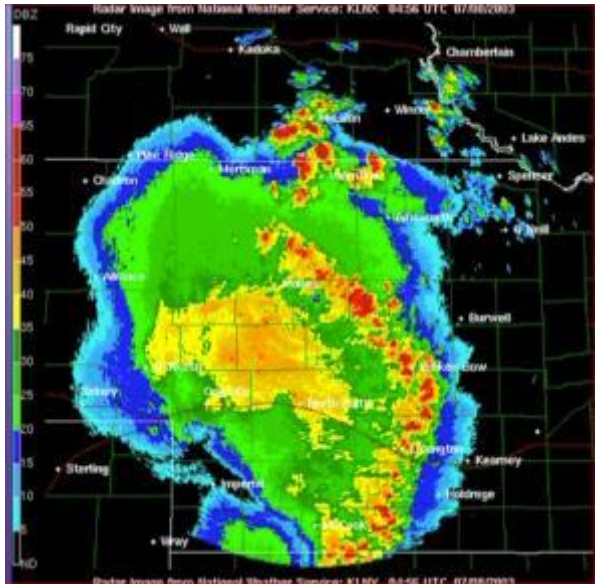


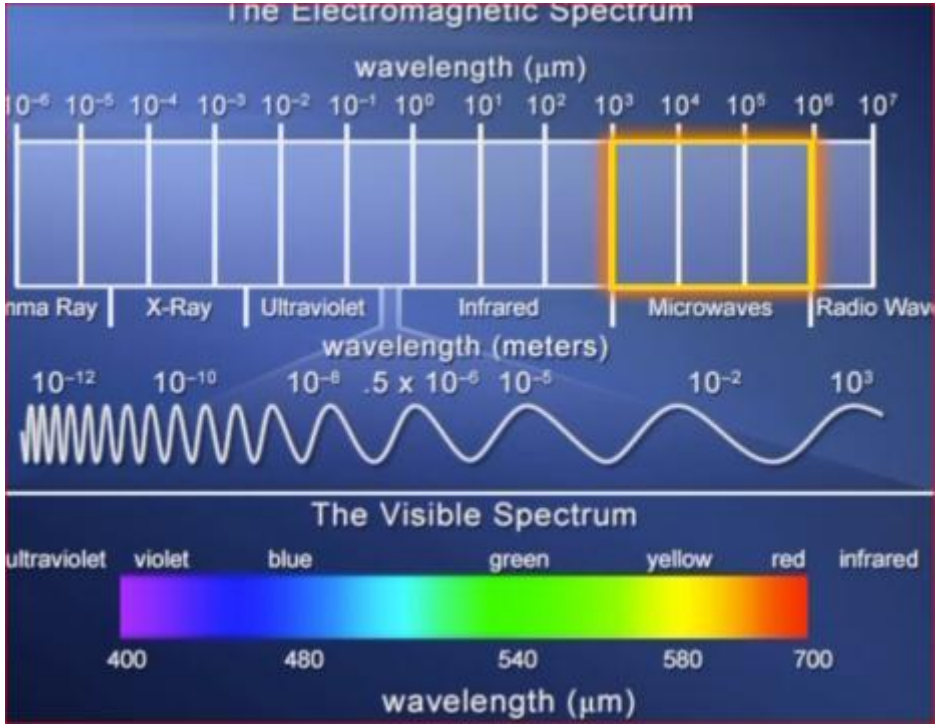


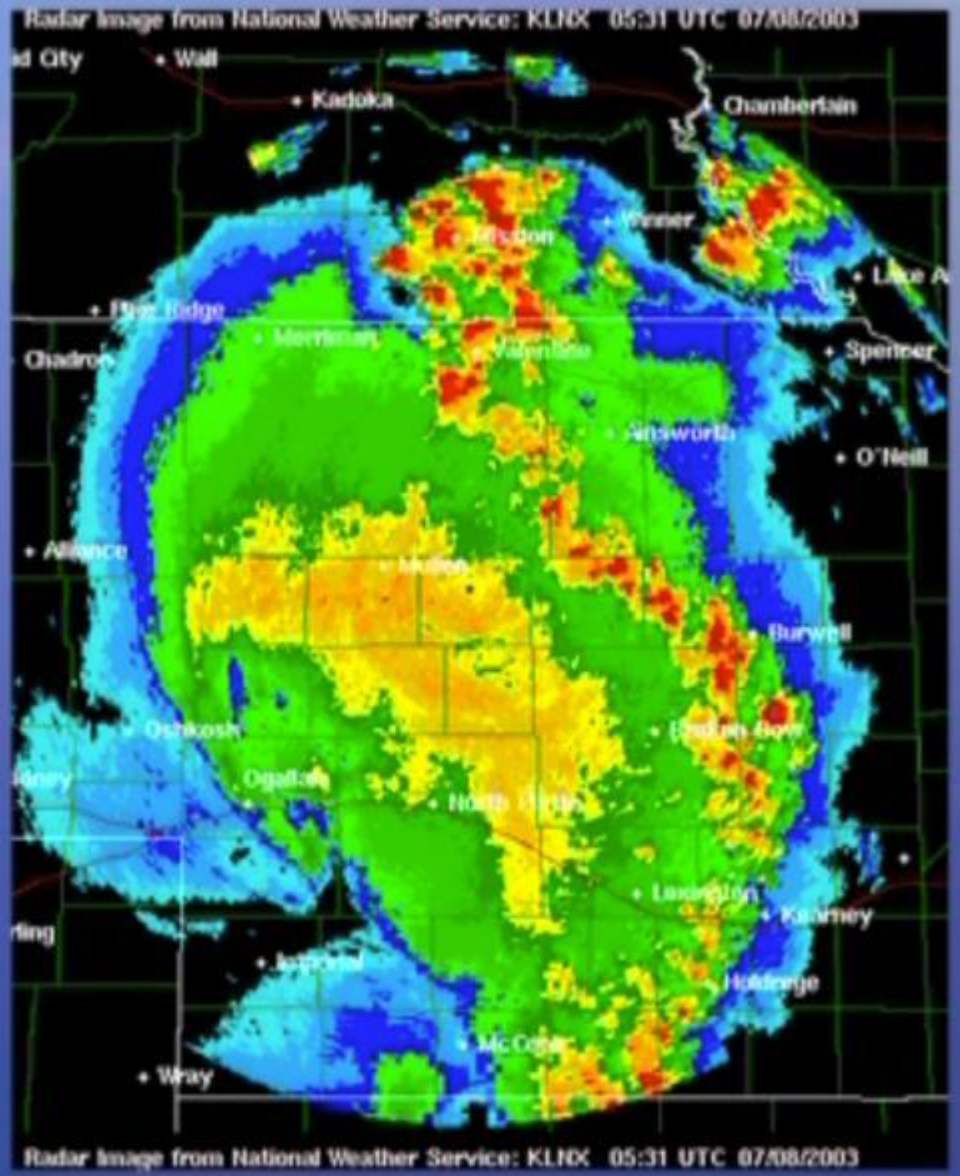
Example: Lincoln, NE July 8, 2003

RADAR
Radio Detection and Ranging

- Videos of radar showing progression and how the data was collected



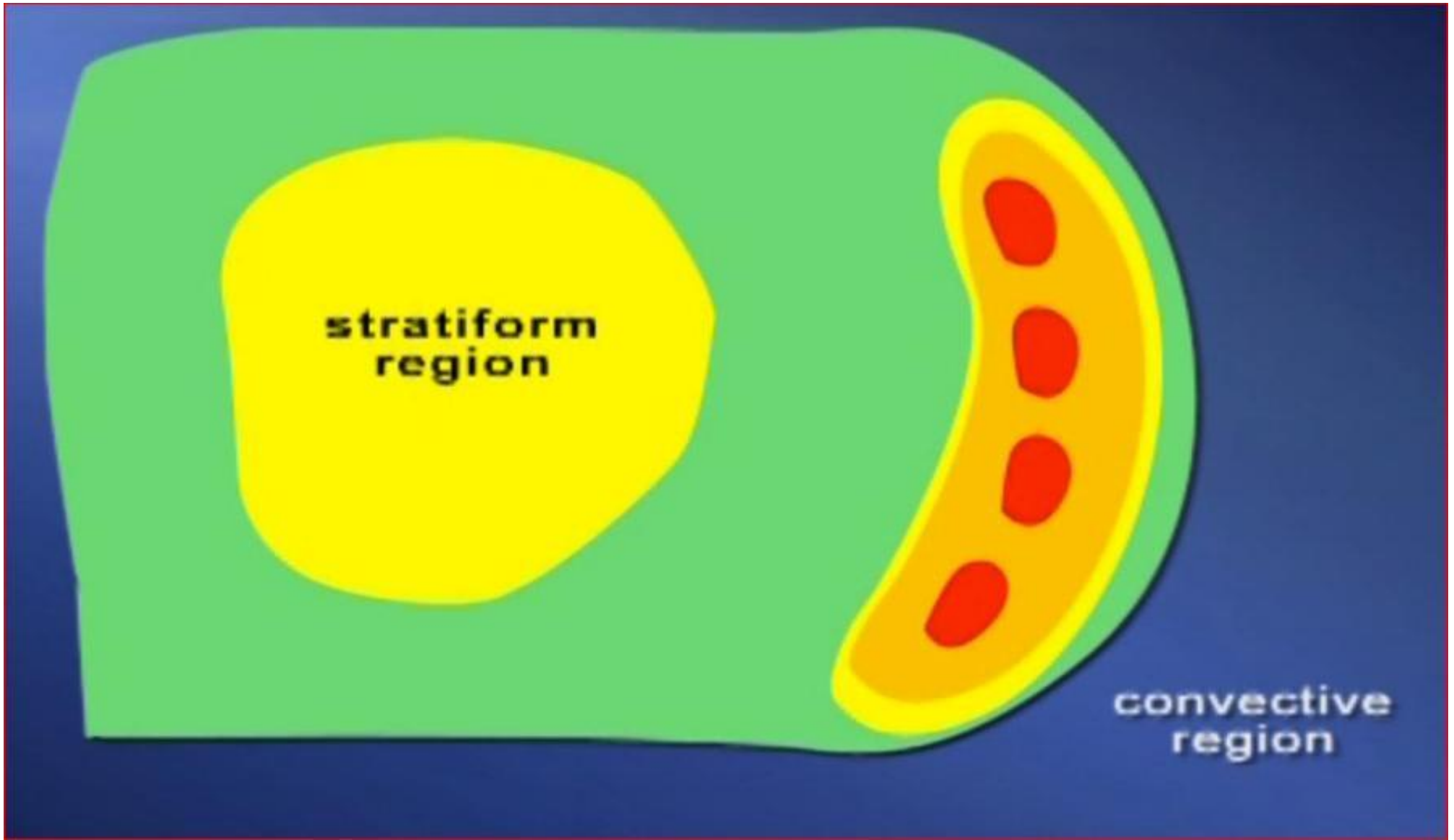




Squall Line Characteristics

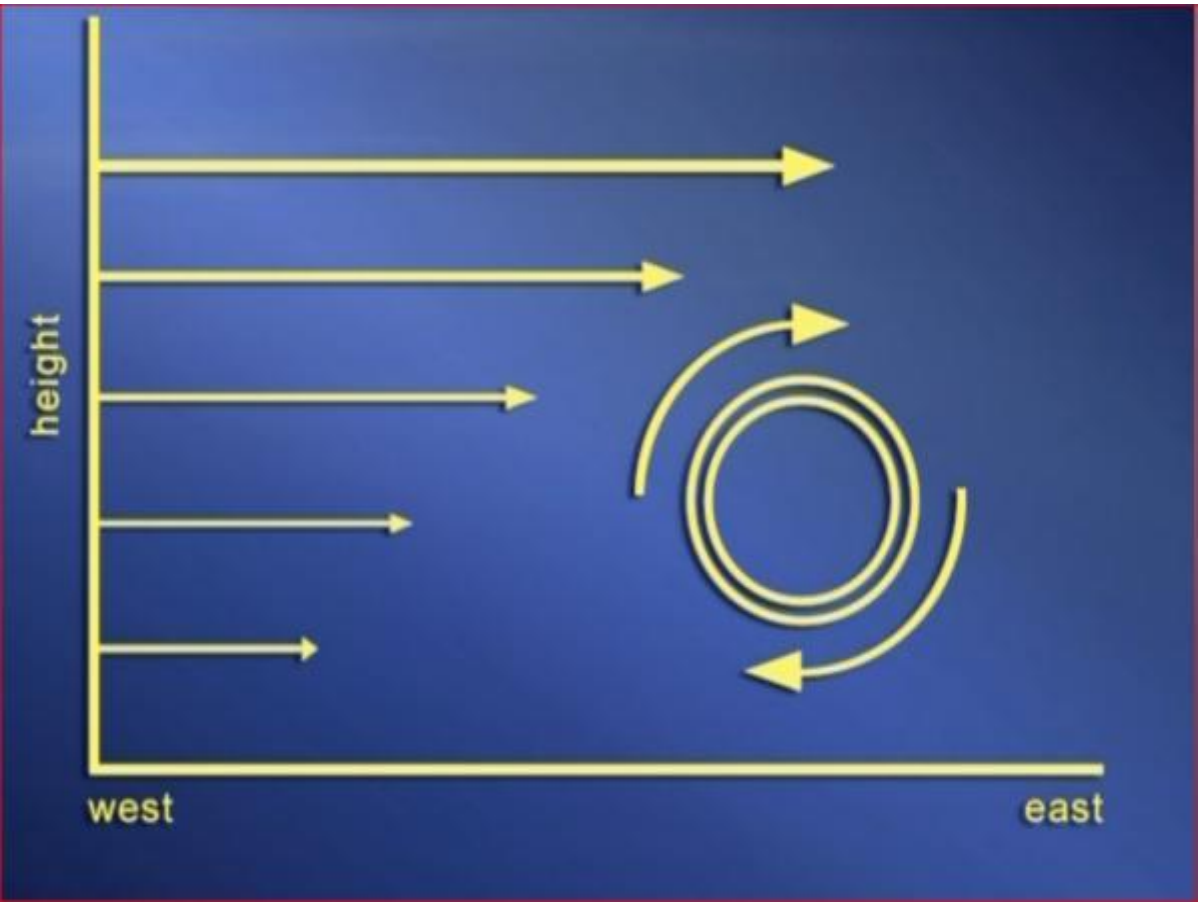
- long-lived
- unsteady
- multicellular
- evaporationally produced sub-cloud cold pools

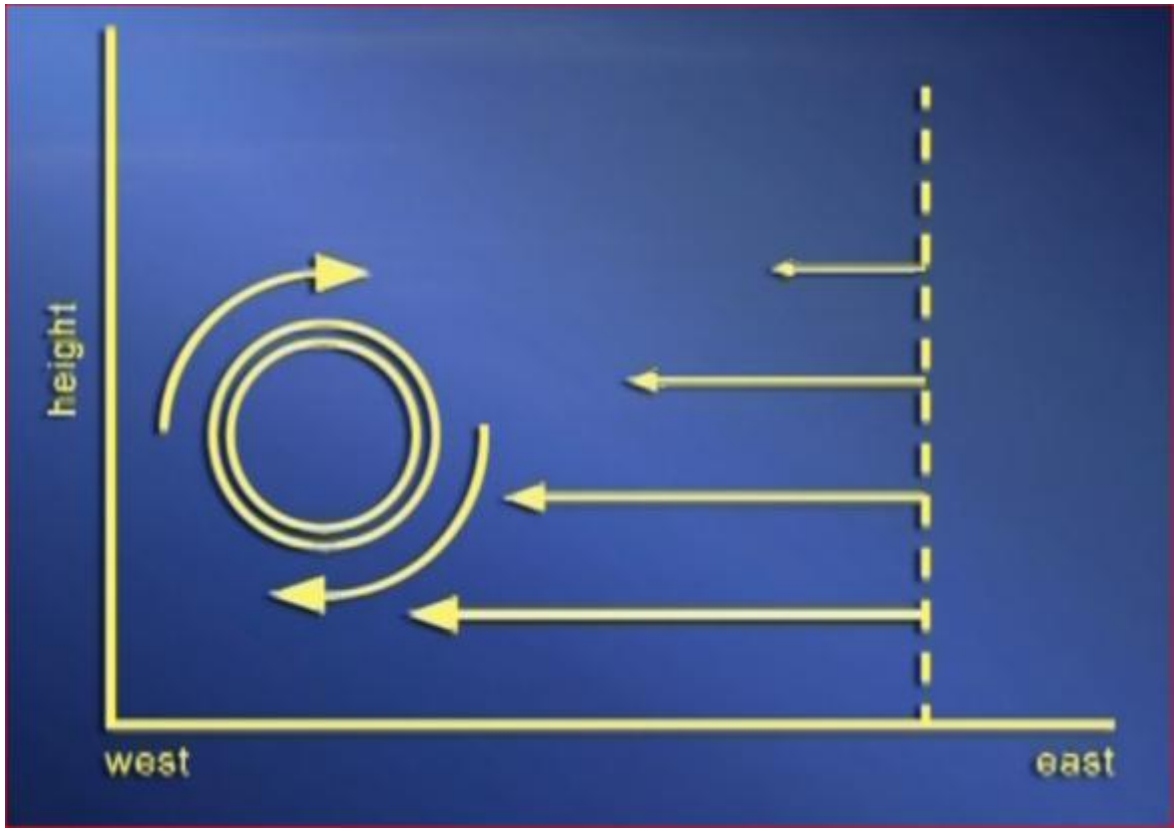
Squall Line Thunderstorms

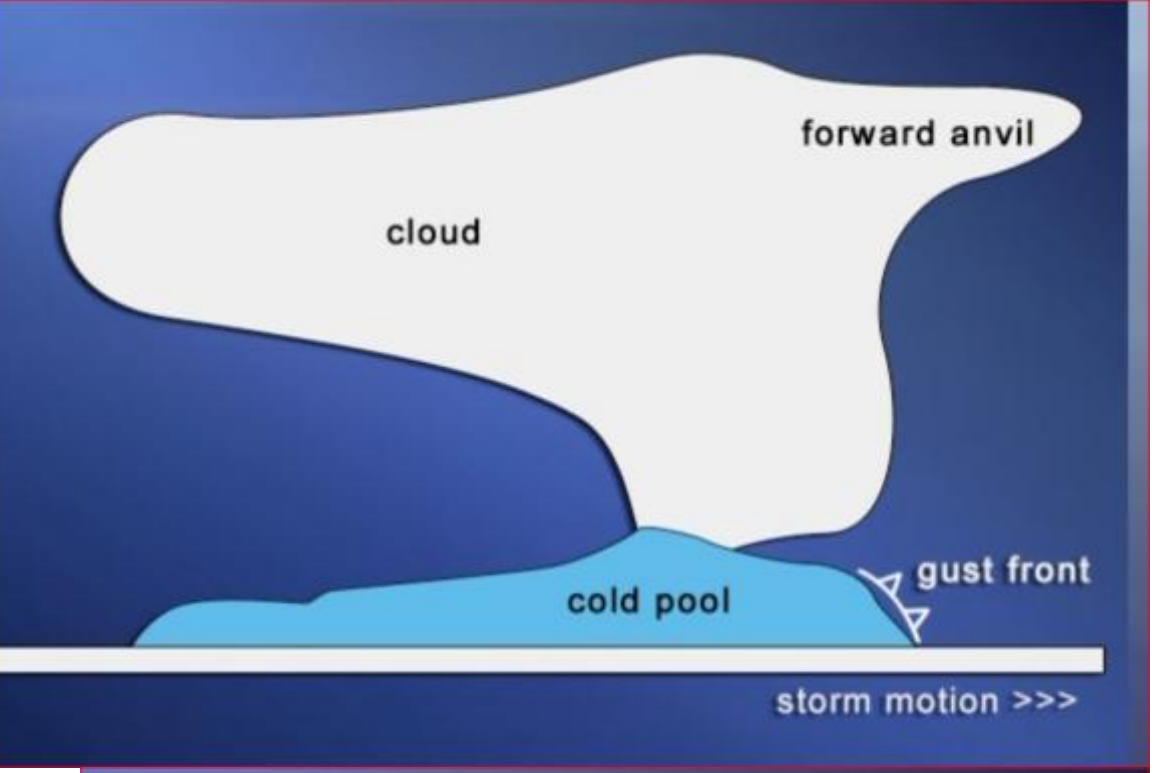


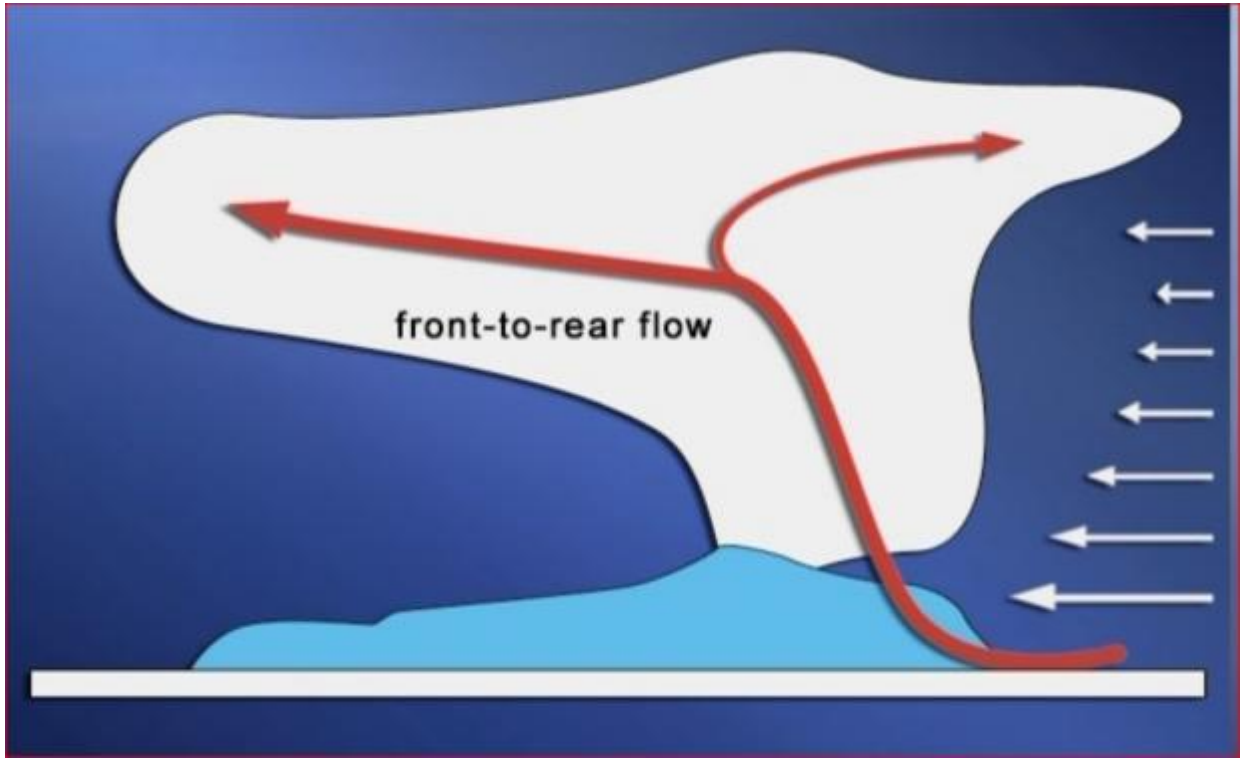
Wind Shear & Vorticity

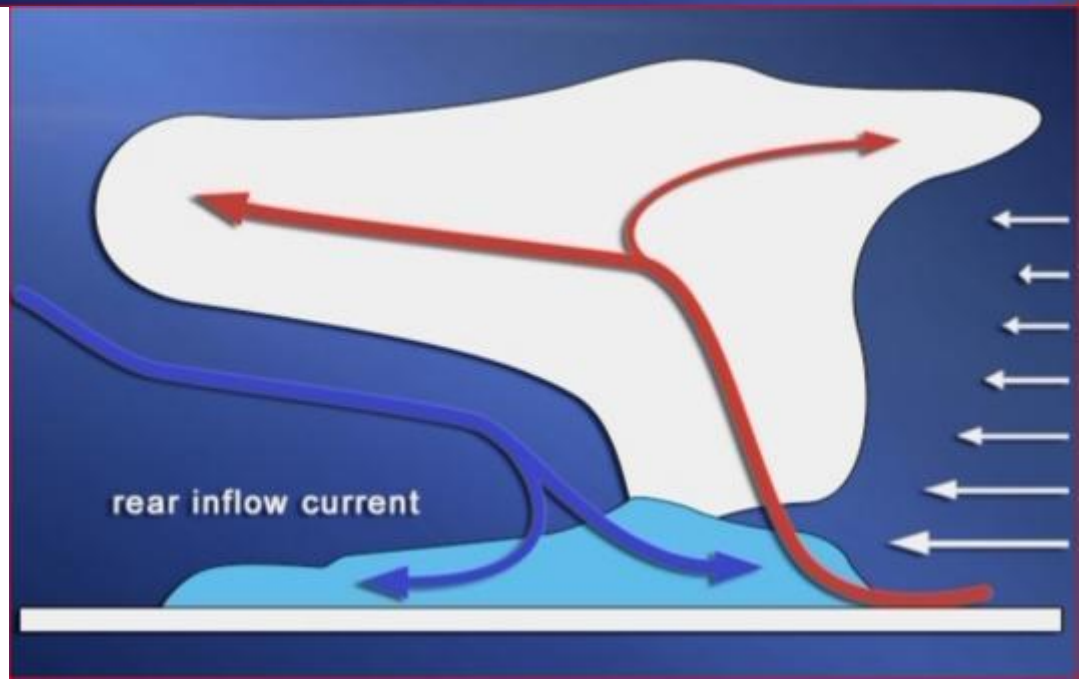
- Shear makes spin – horizontal vorticity = creates low pressure
- Upper winds moving east faster than counterflow winds as in lower atmosphere

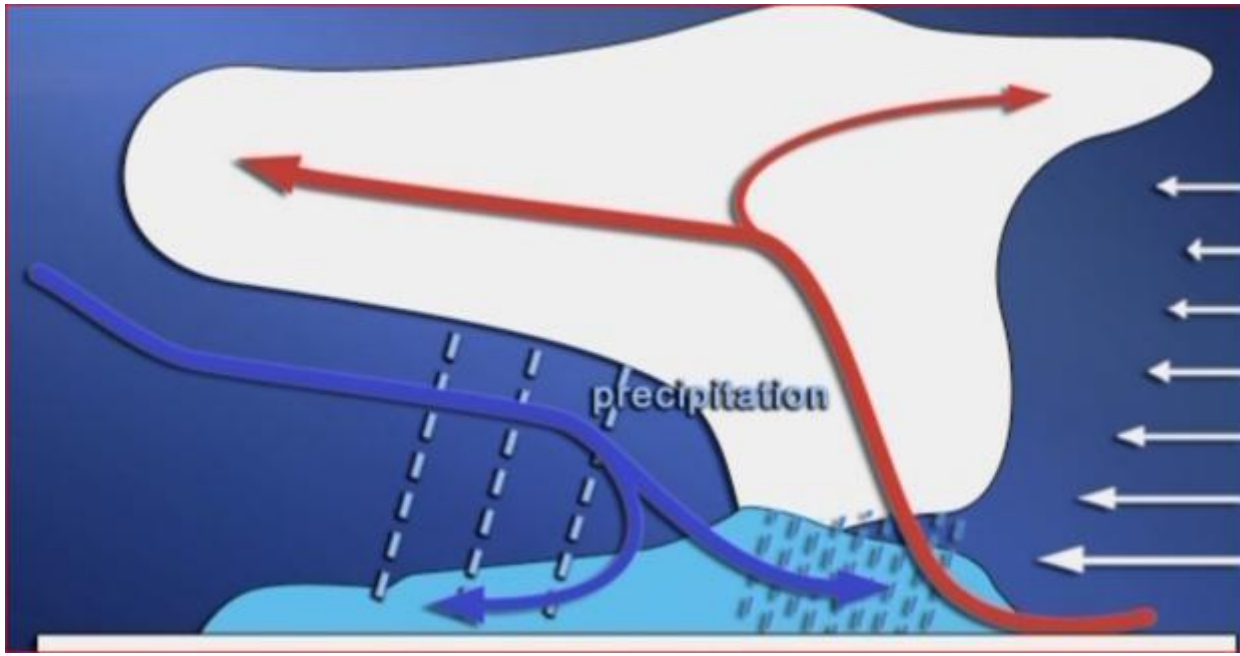





forward anvil
cloud
gust front
cold pool
storm motion >>>

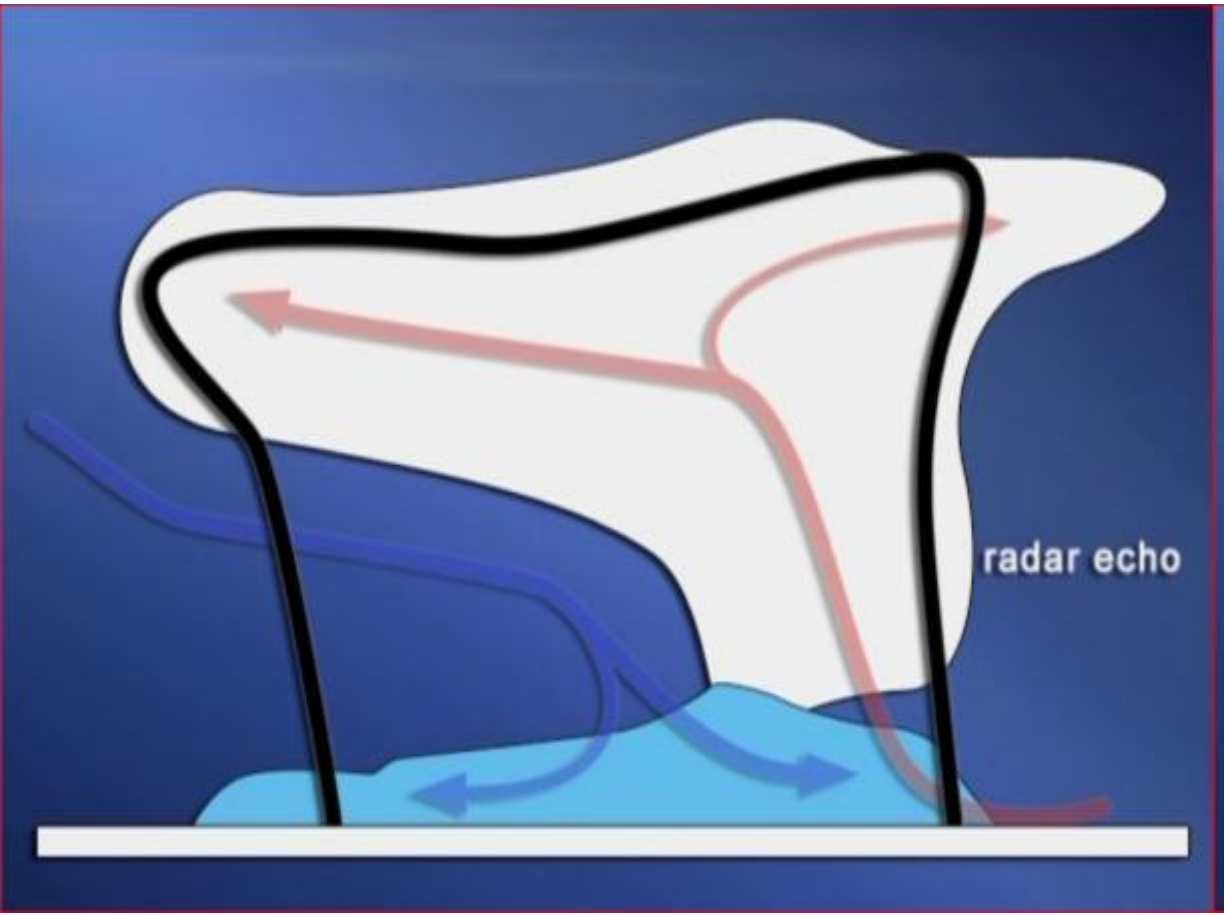

front-to-rear flow

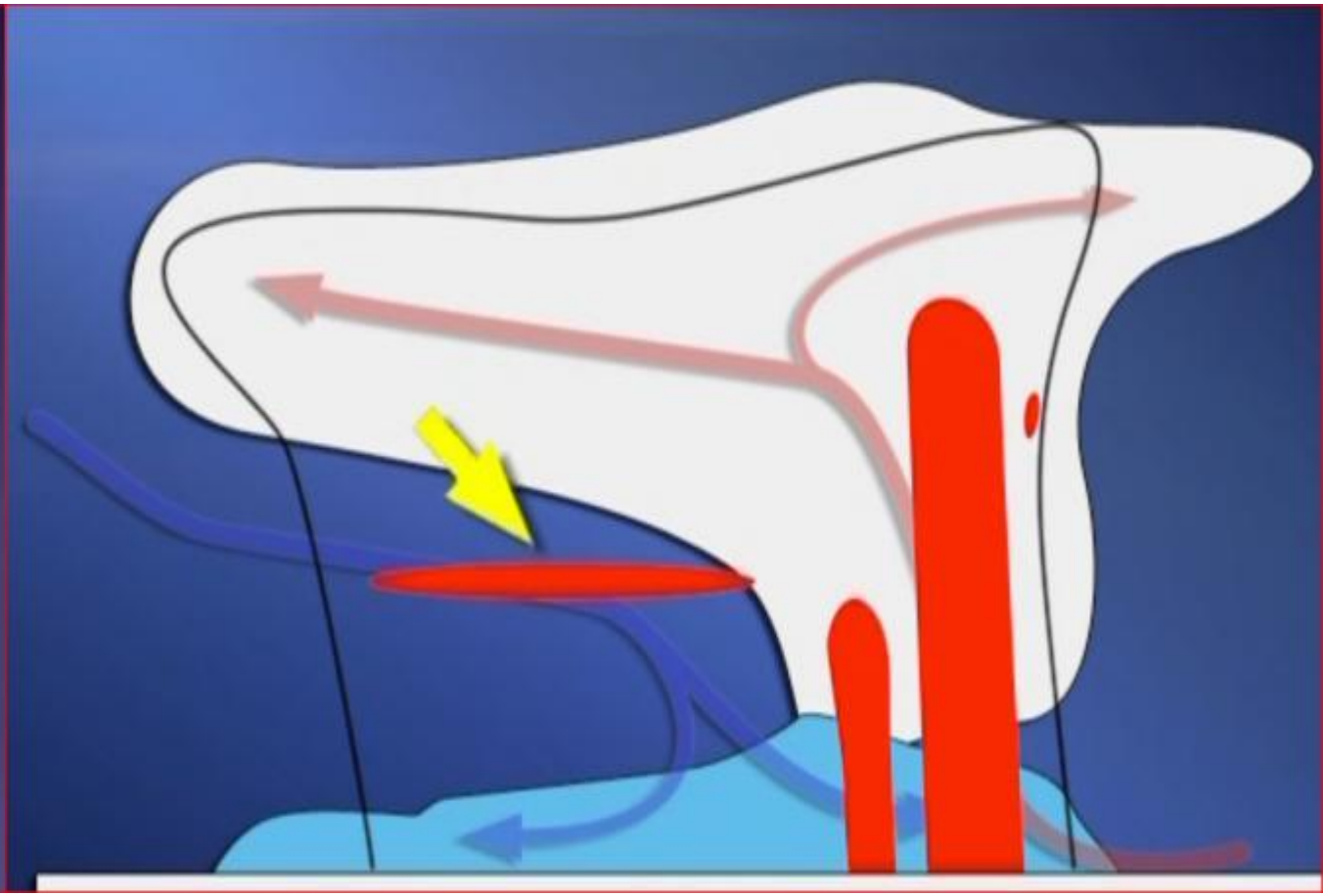

rear inflow current


precipitation

The part visible to 10 cm (2.54 cm/in) radar

- Squalls, their structure and lives

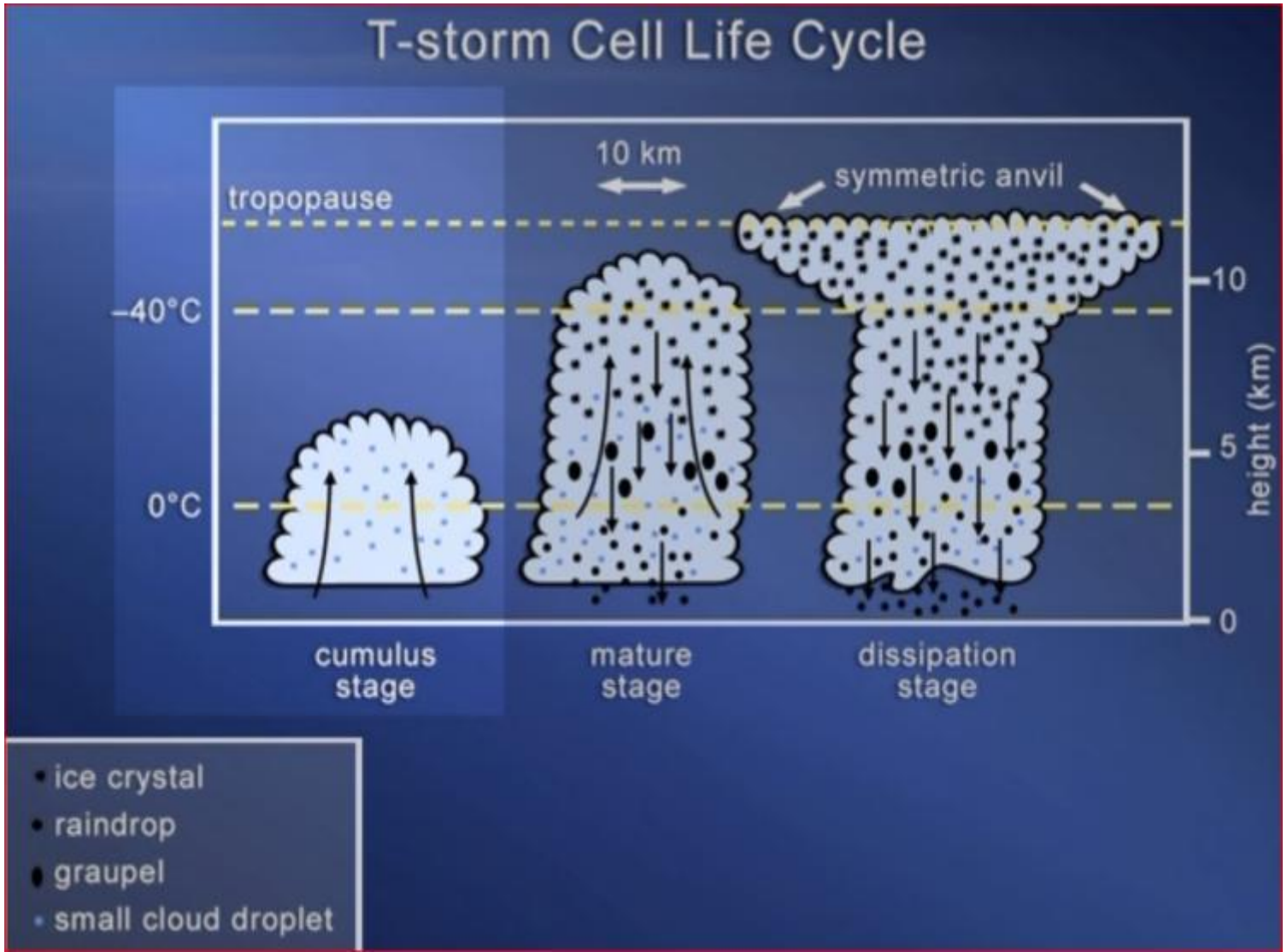


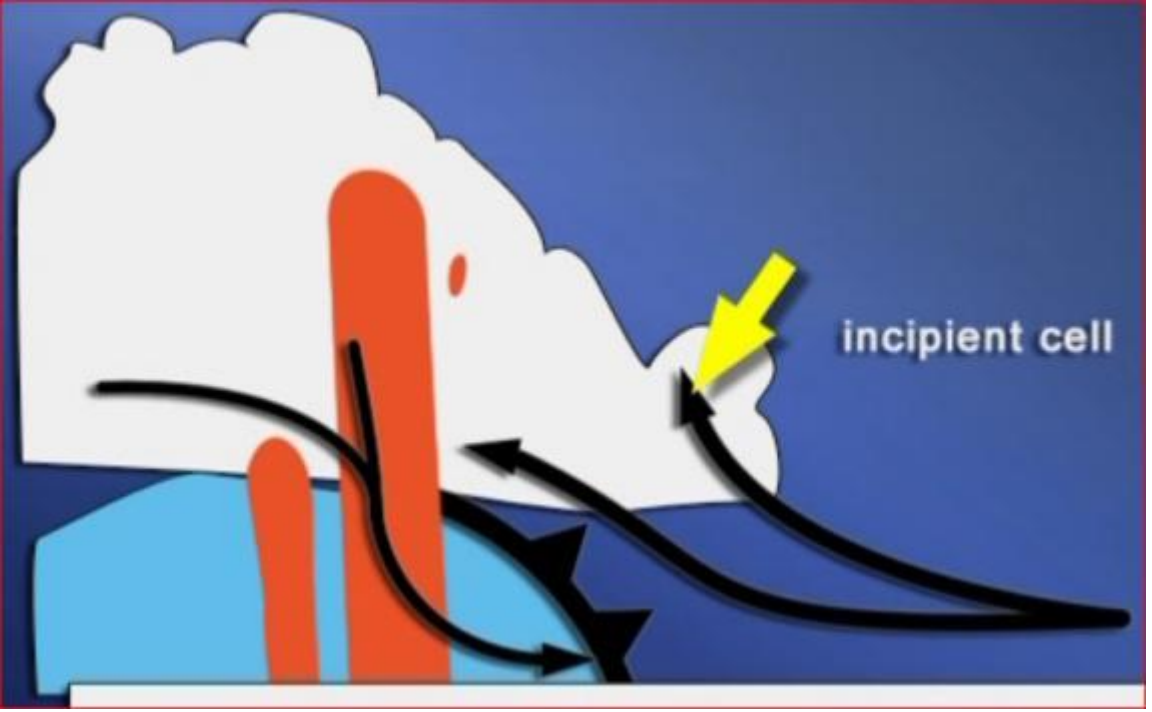


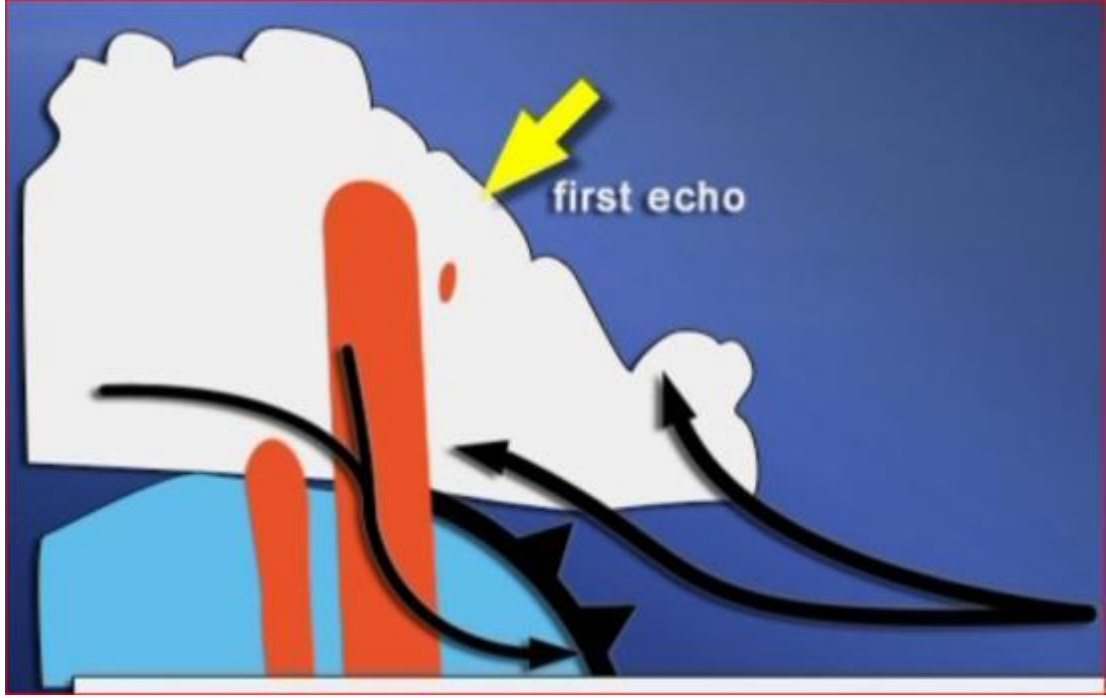
The Thunderstorm Project: crash that killed senator put it “on congress’ radar”

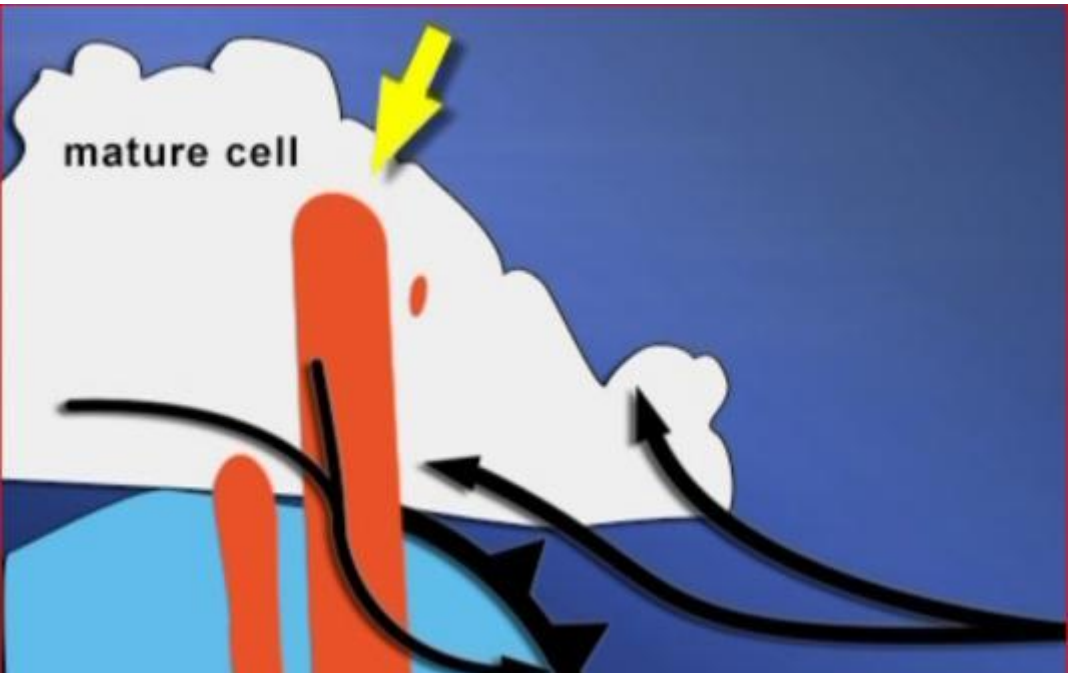
- Provided an understanding of the thunderstorm life cycle

ONE CELL CYCLE



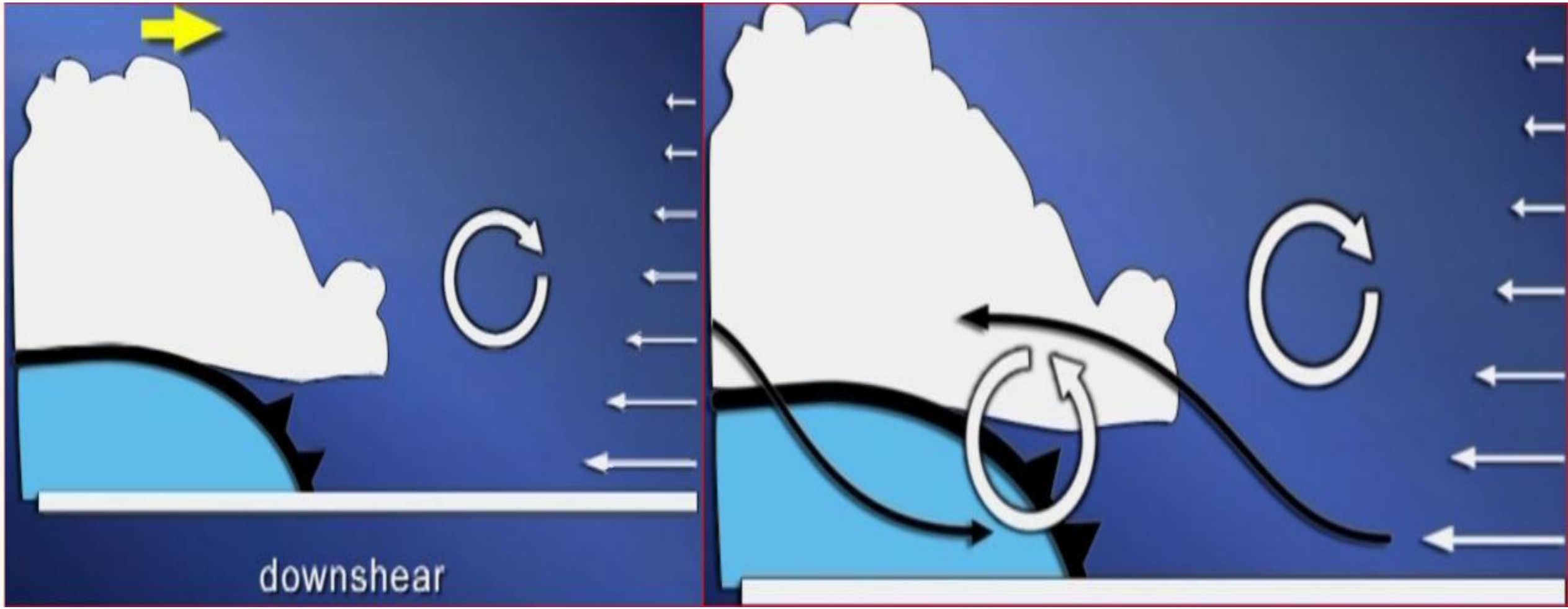

incipient cell


first echo

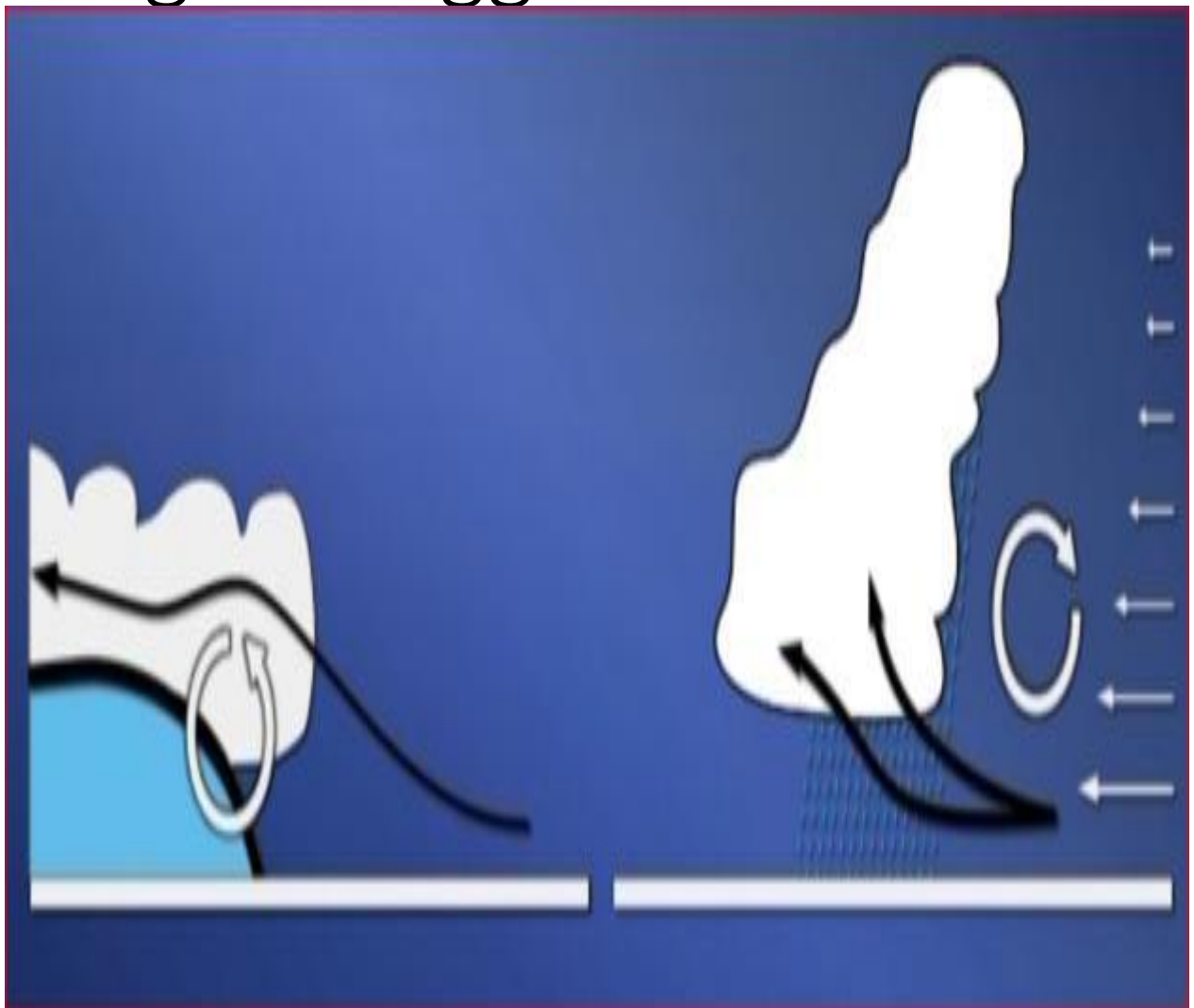

mature cell

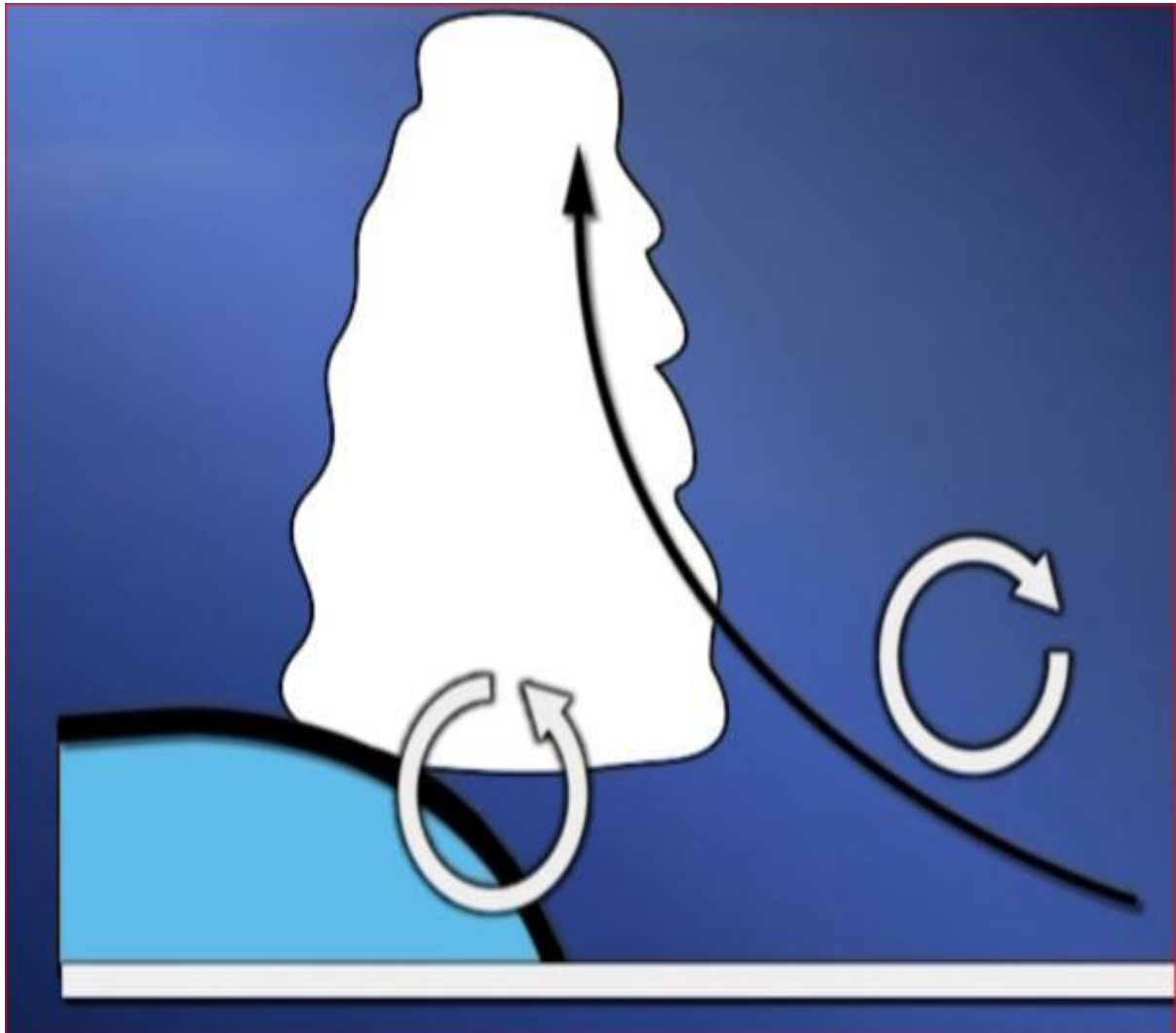

dissipating
cell

Competitive circulation



Cold pool circulation and circulation that has virga that cools and moistens the air – when combined get a bigger storm



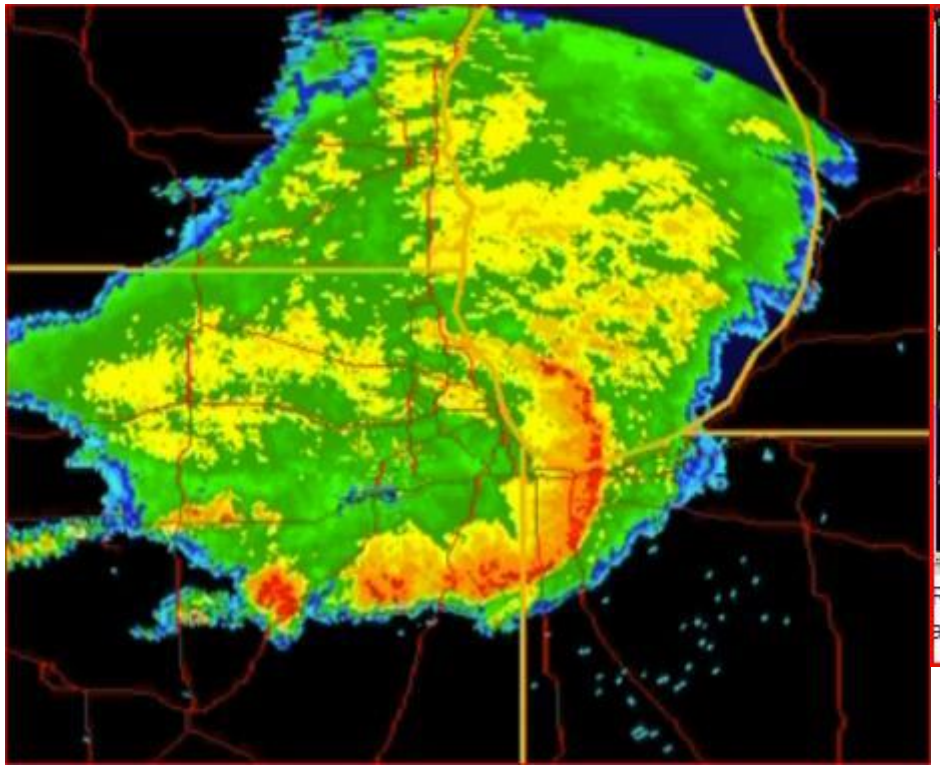


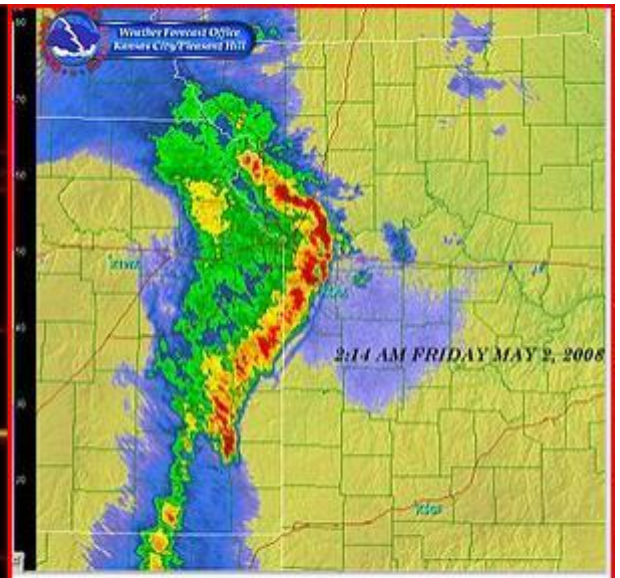
Third circulation

Squall Line Echo

bow echo
derecho

- Bow echo: https://en.wikipedia.org/wiki/Bow_echo
- Derecho: https://en.wikipedia.org/wiki/Derecho

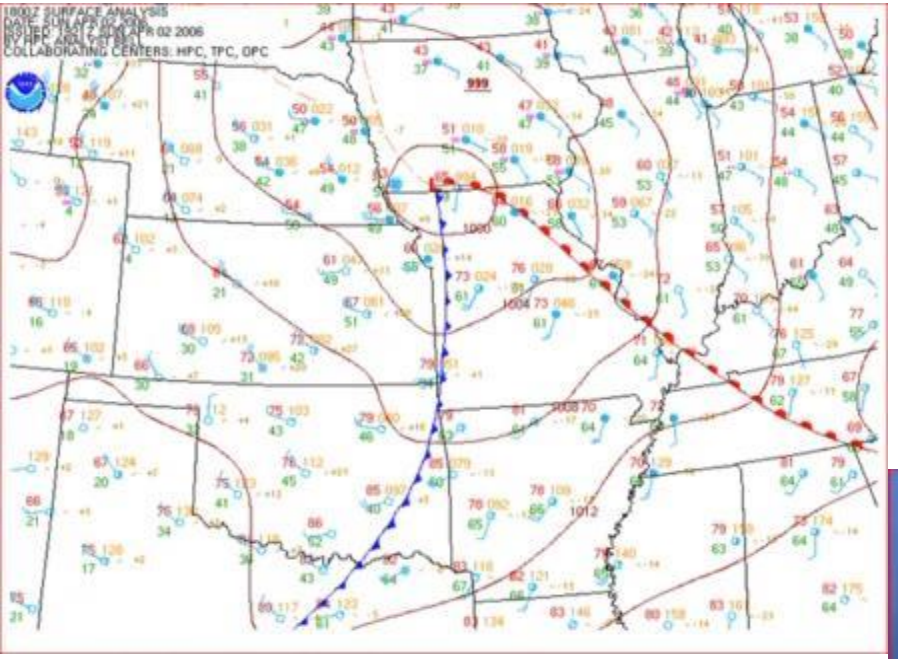


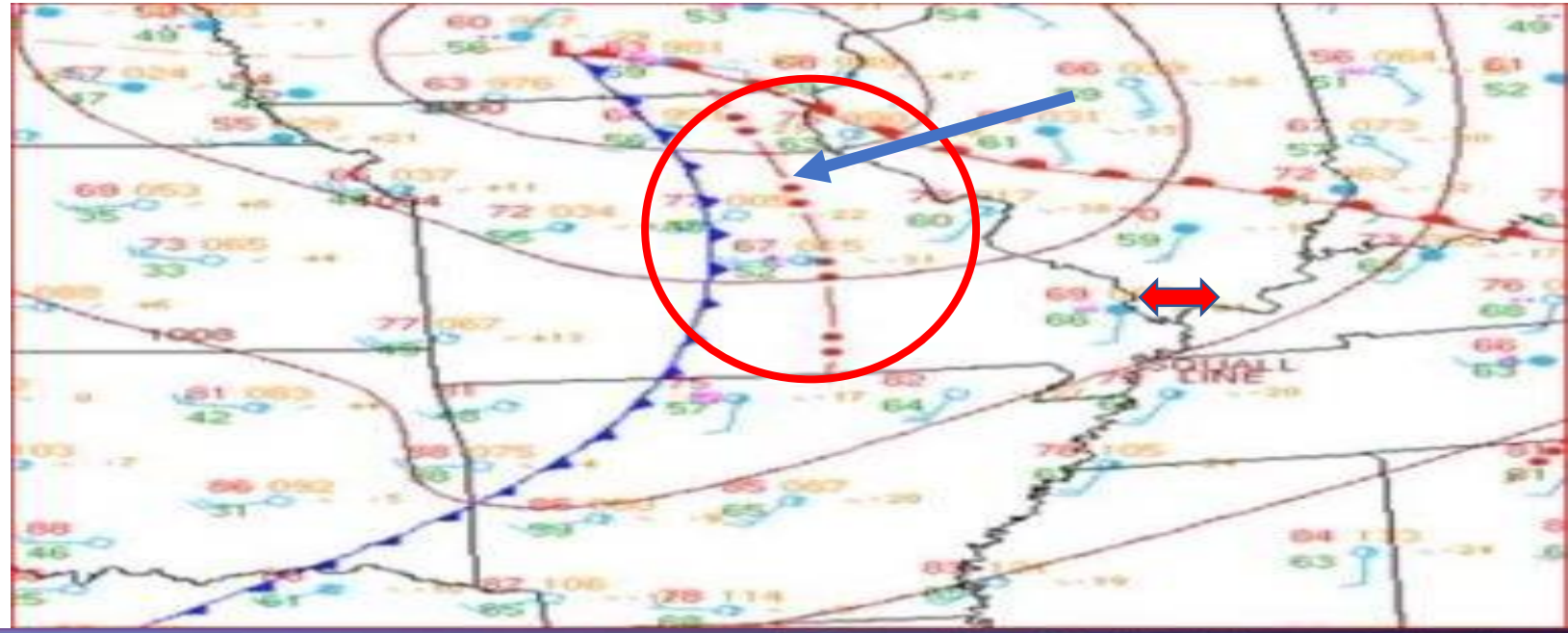


Radar image of a bow echo crossing Kansas City at 2:14 AM on 2 May 2008 (NWS Kansas City)

A shelf cloud along the leading edge of a derecho photographed in Minnesota

Squall Lines & Fronts

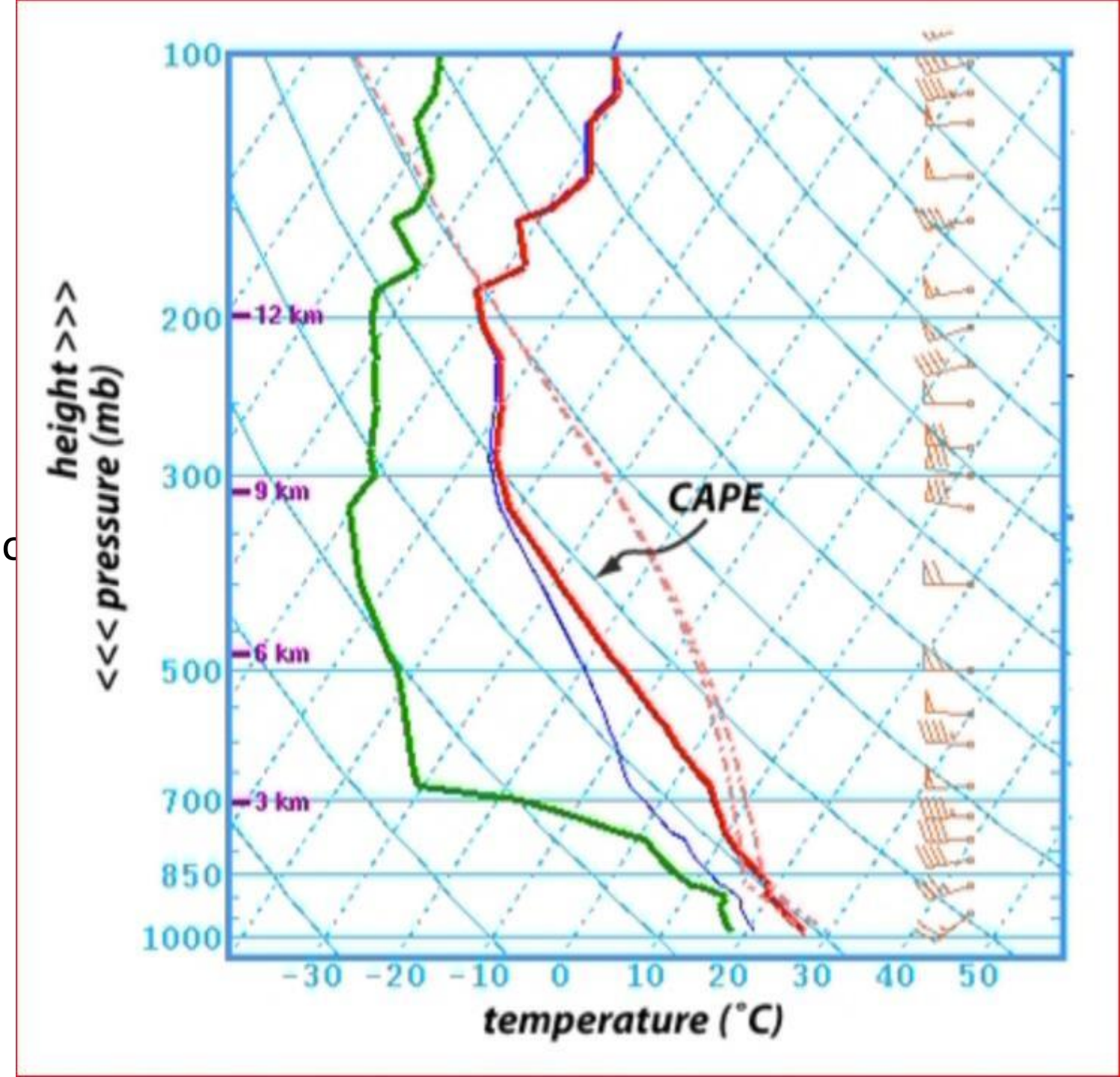




C-P DIAGRAM

- CAPE = Convective Available Potential Energy
- Environmental Lapse Rate & Convective Lapse Rate showing available energy for convection o an air parcel

CAPE:
https://en.wikipedia.org/wiki/Convective_available_potential_energy



REVIEW CHAPTER 18

- HOW SQUALL LINE WORKS
- AND HOW IT SHOWS ON RADAR
- CONVECTIVE CELLS DESTROY THEMSELVES BUT OTHERS FORM.
- 30-40 MINUTES LIFE OF A CELL
- SQUALL LINE – WIDENS from cool front at it progresses

METEOROLOGY

An Introduction to the Wonders of the Weather

Lecture 19

Supercells, Tornadoes, and Dry Lines

Mesoscale Convective System (MCS)

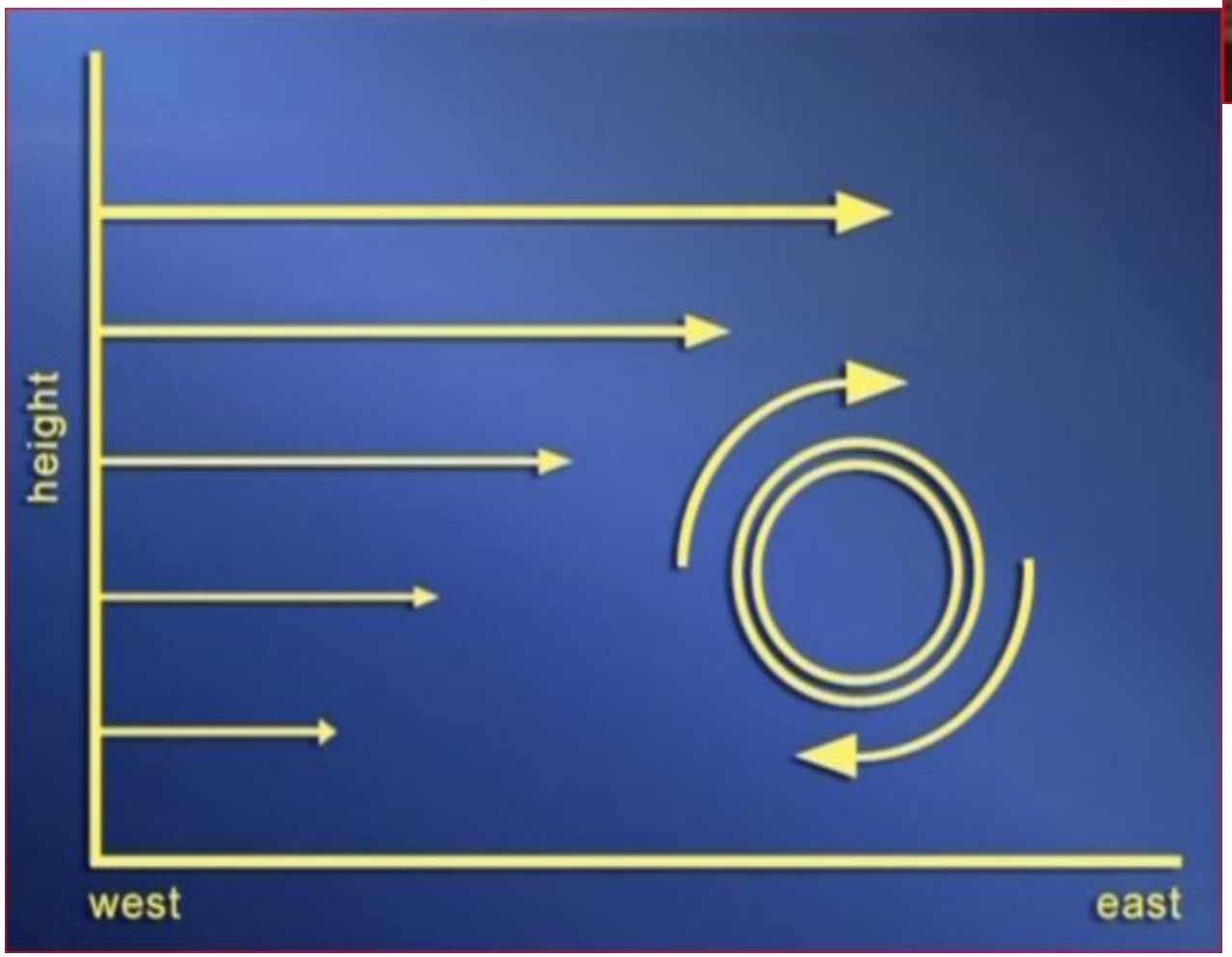
Last Lecture:

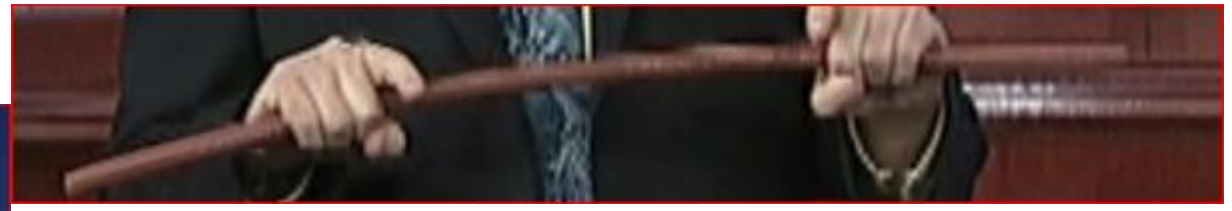
- Weather radar
- Squall lines – a TYPE OF MCS, Mesoscale Convective System: https://en.wikipedia.org/wiki/Mesoscale_convective_system

This Lecture:

- SUPERCELL thunderstorms - another type Mesoscale Convective System – organized convection
- Dry lines: https://en.wikipedia.org/wiki/Dry_line - trigger storms

Vortex Tube – Starts with vertical rotation, horizontal axis

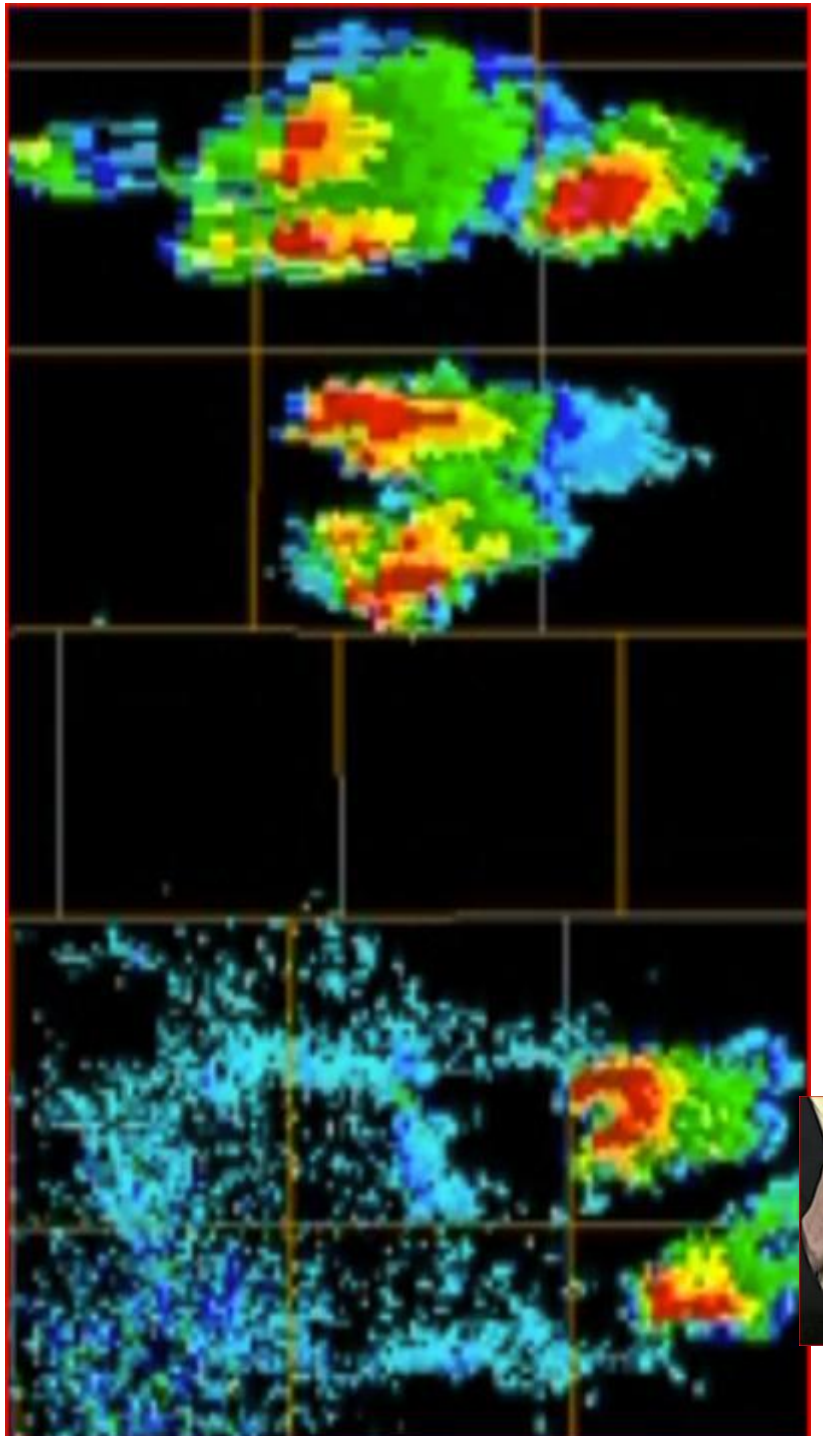


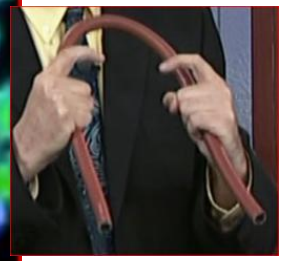


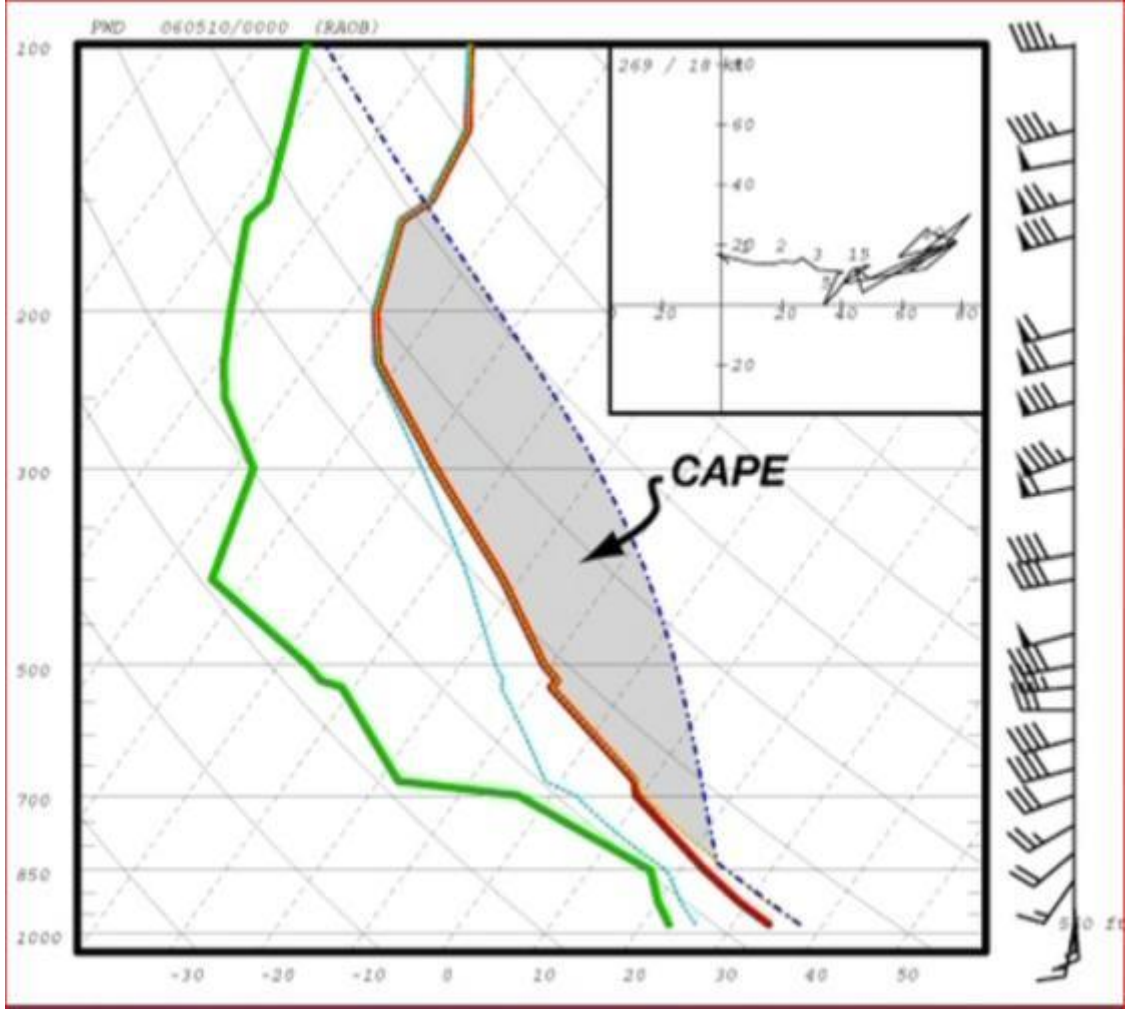
IF TILTED:
Tube gets tilted
and there's rotation
opposite with spin
in Horizontal plane

Counter rotating supercells

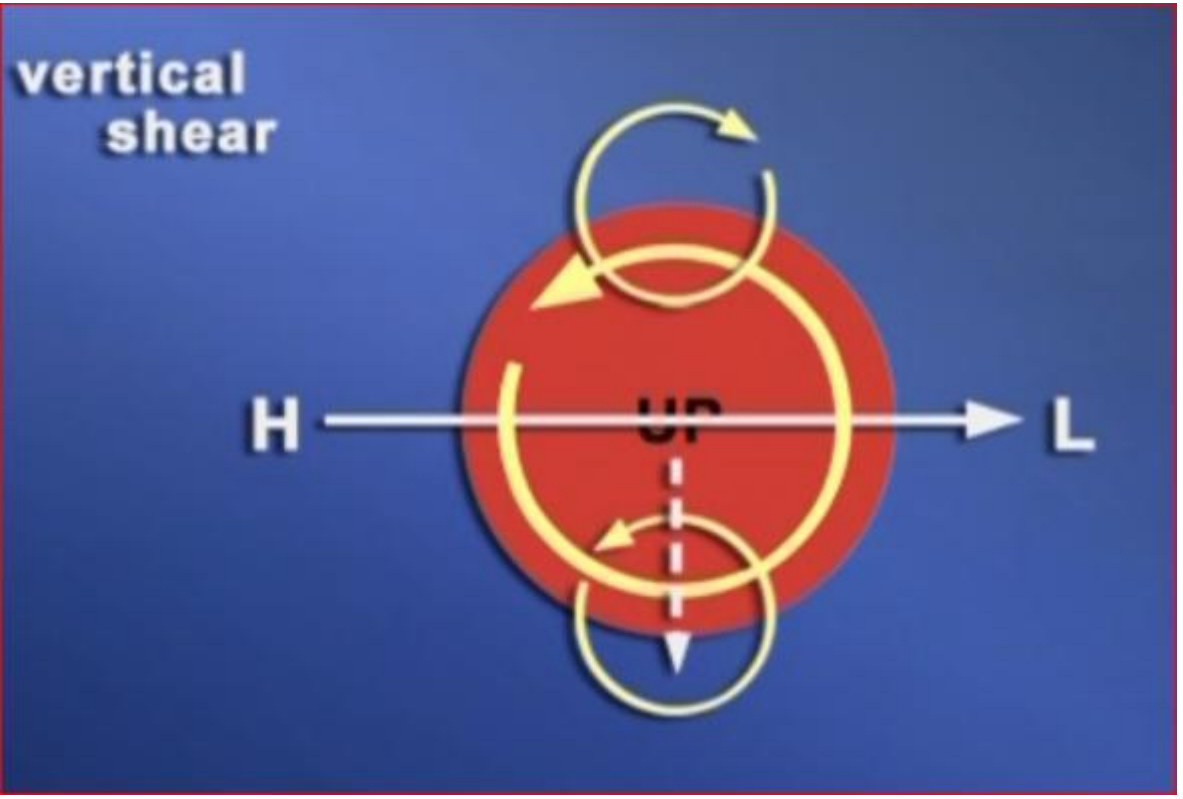
Several supercells

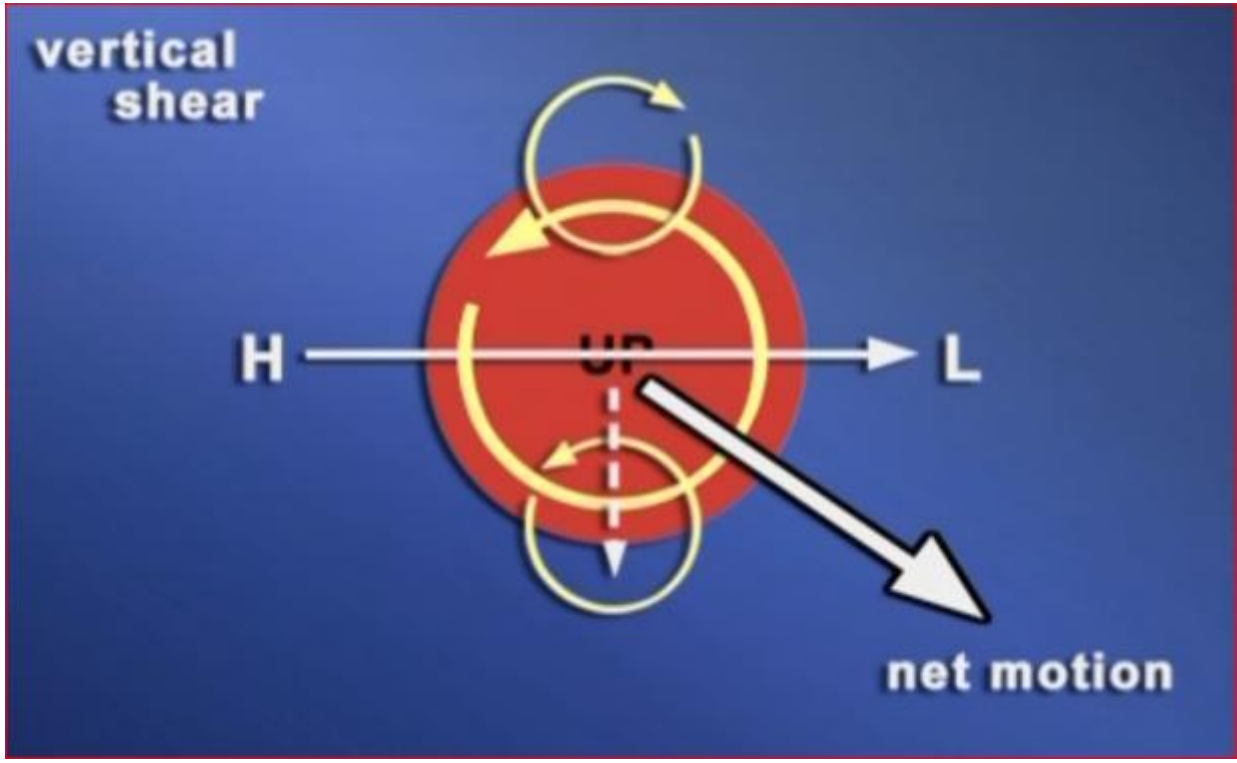




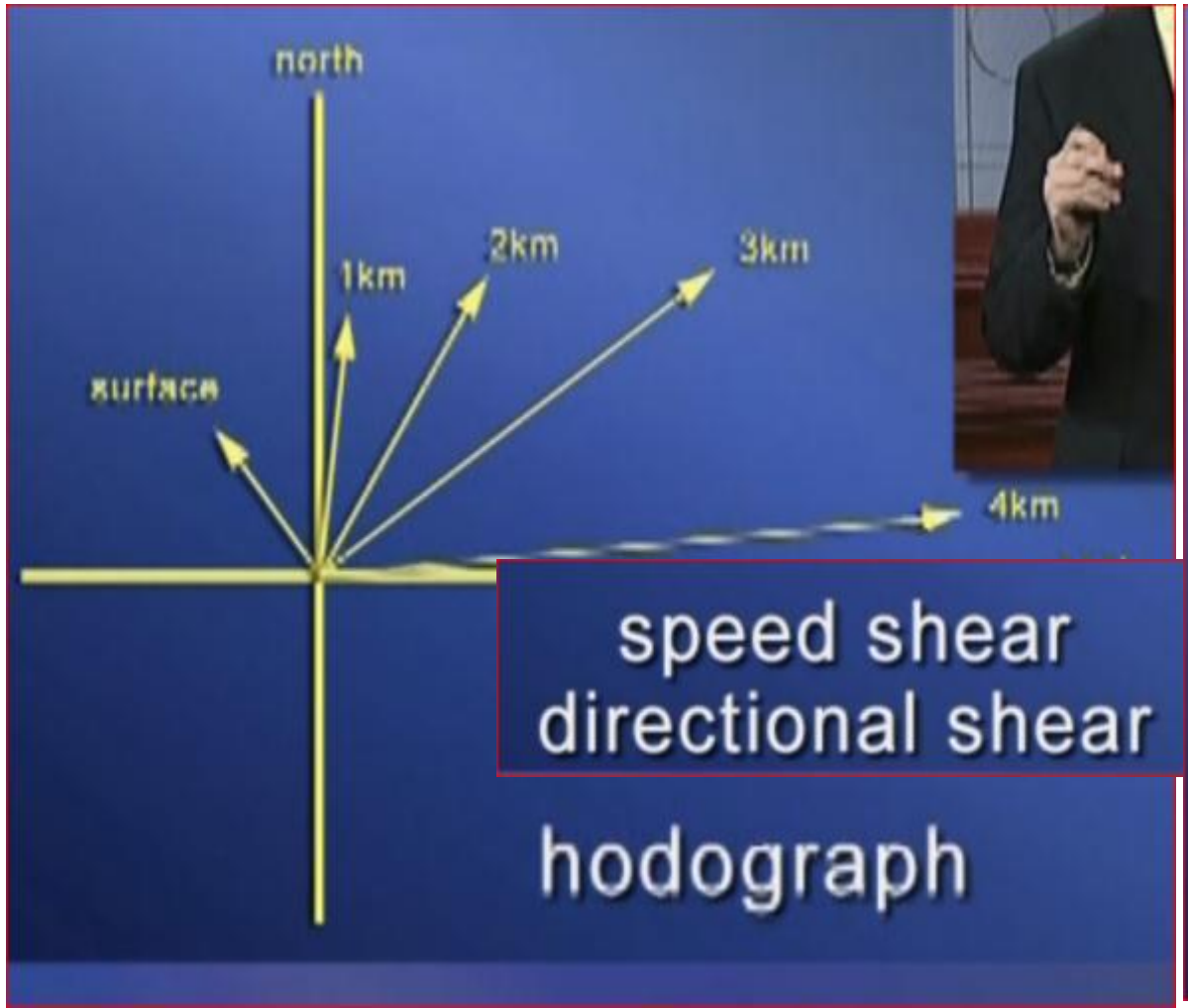


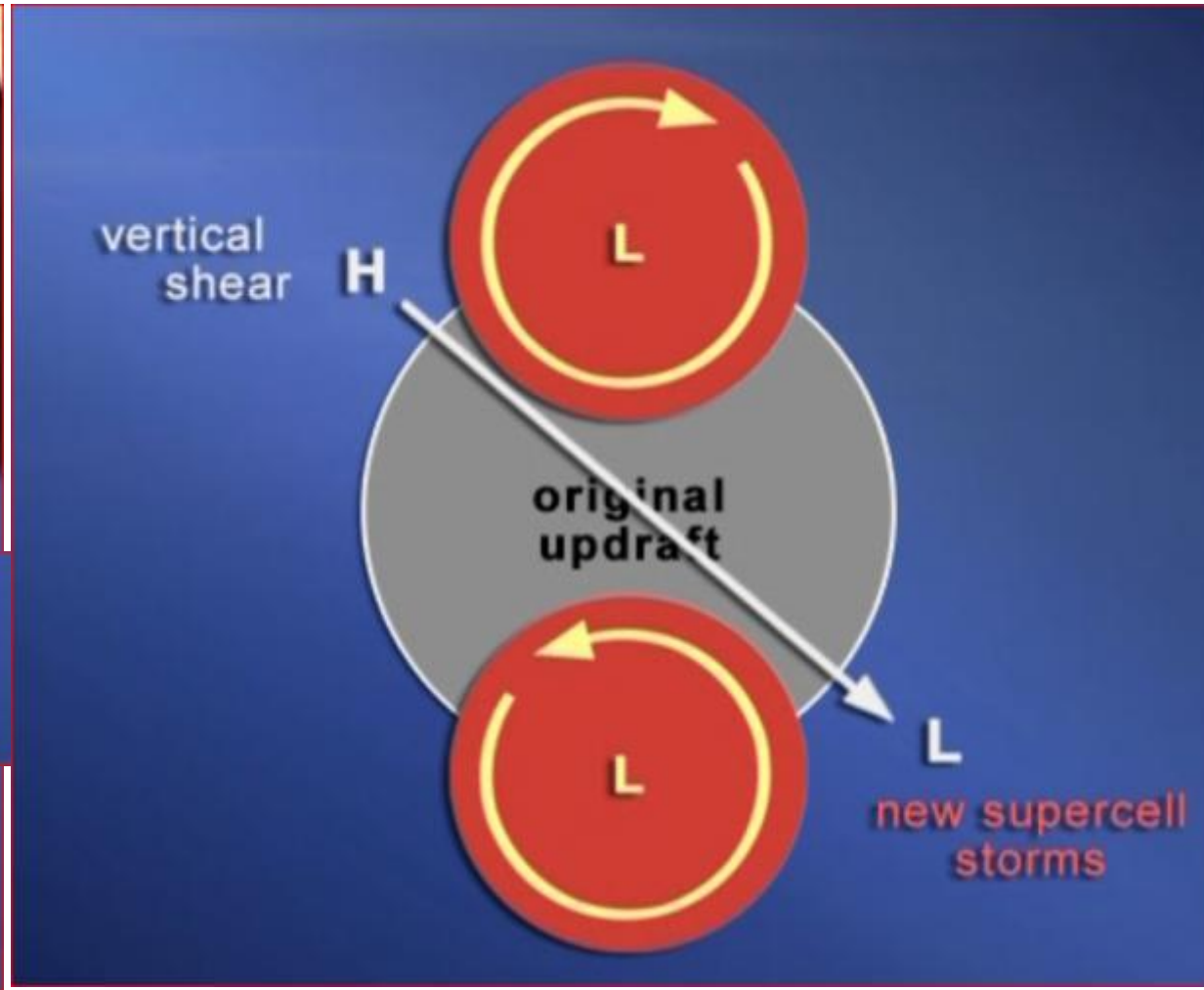
CAPE: air parcel with temperature greater than atmospheric lapse rate
https://en.wikipedia.org/wiki/Convective_available_potential_energy


vertical
shear
H
UP
L

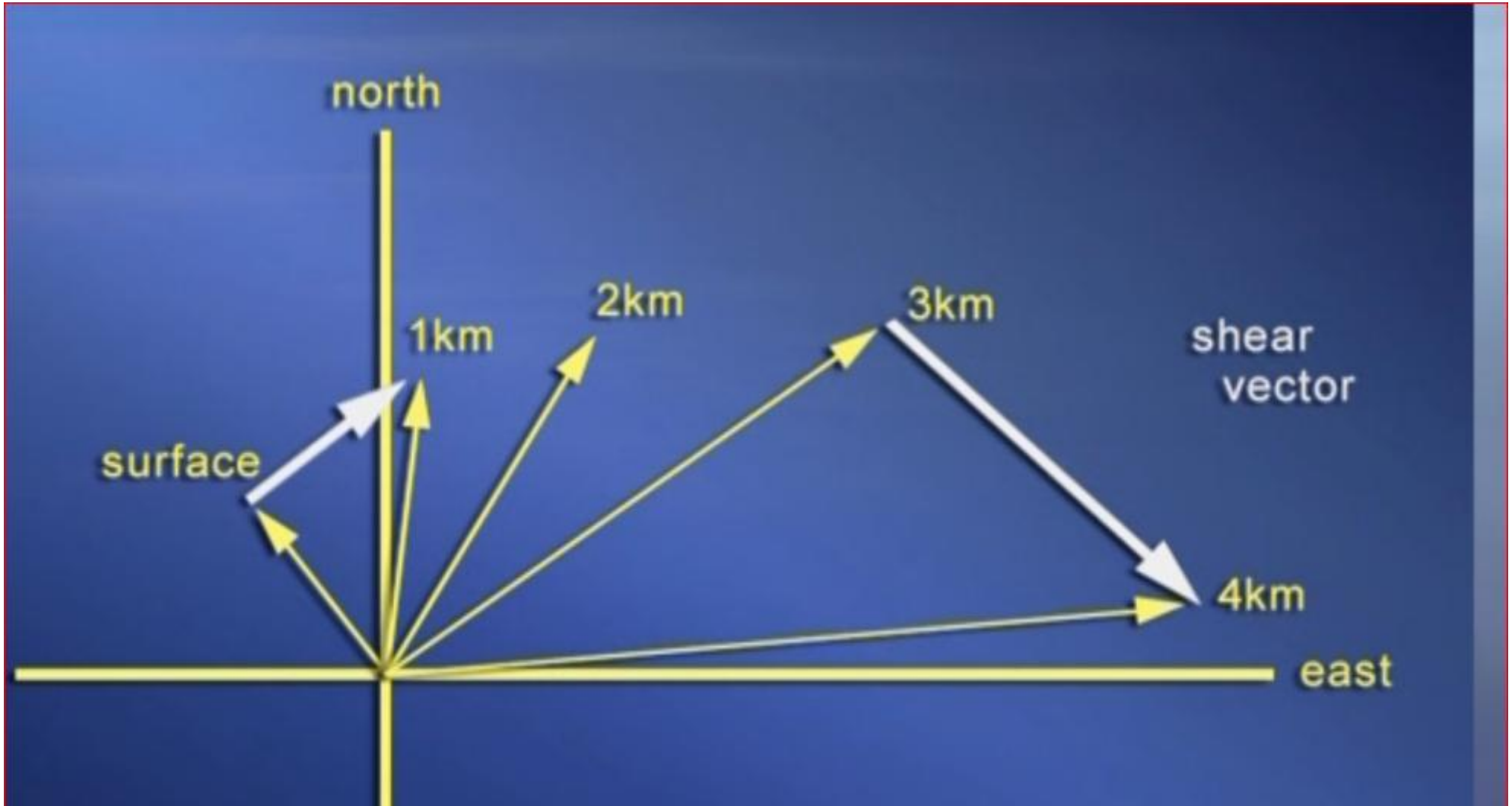

vertical
shear
H
L
net motion

Shear vectors: Strengths & Directions

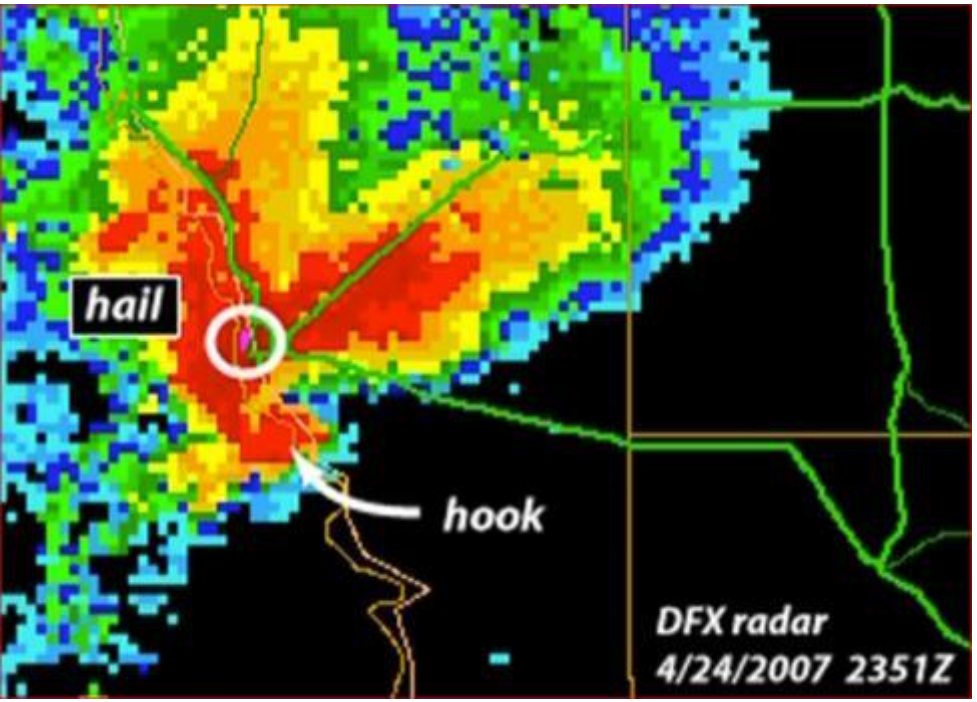


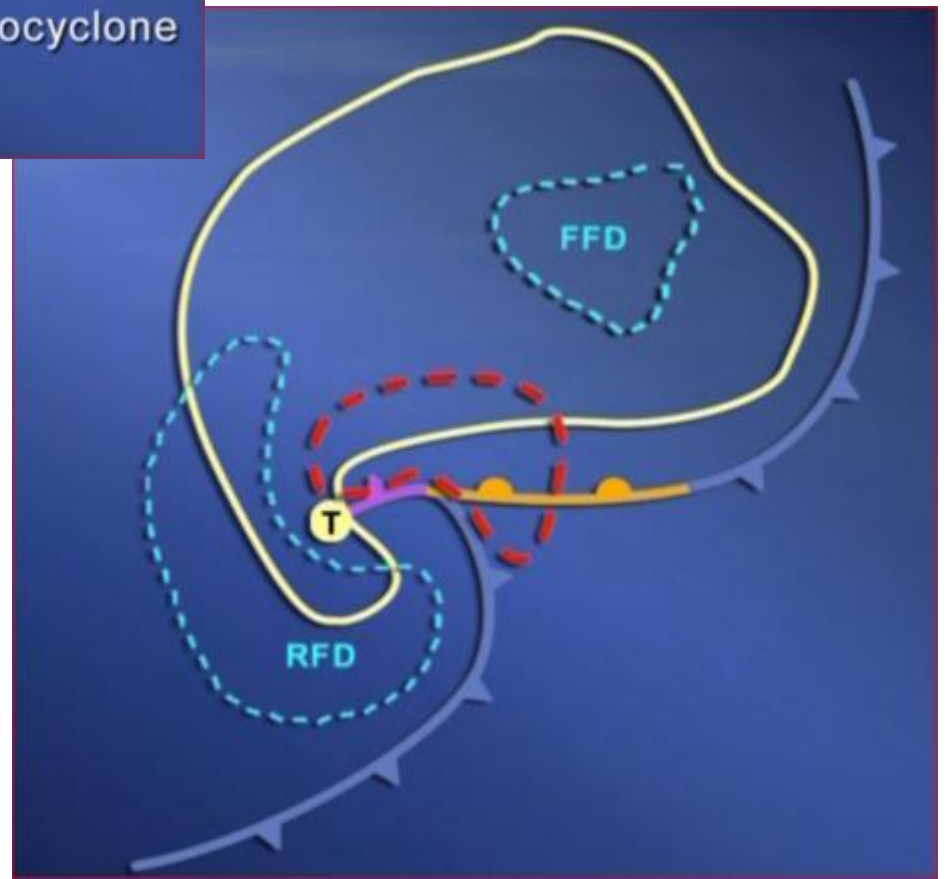


Rotation with Height



Tornado – hook echo

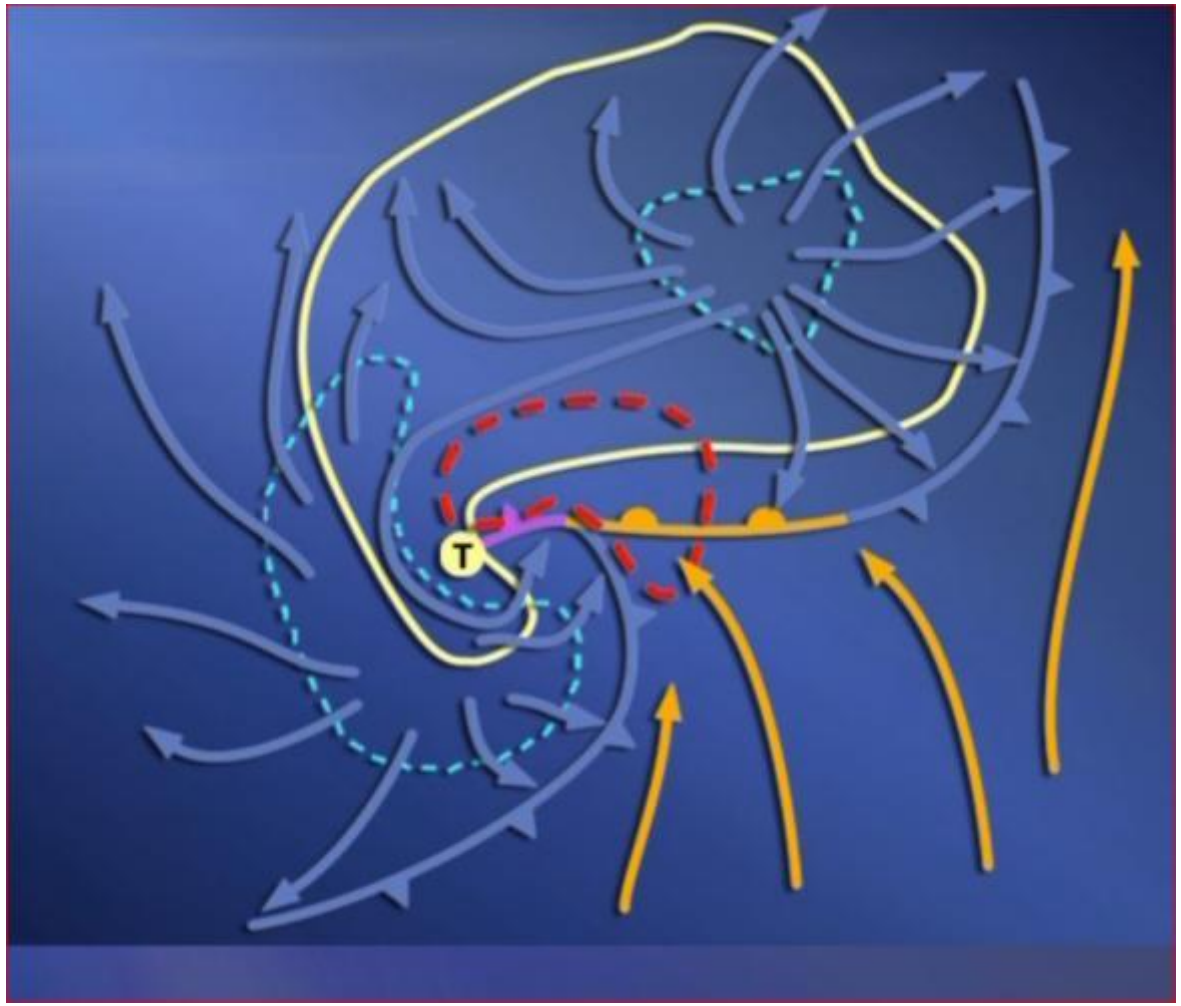


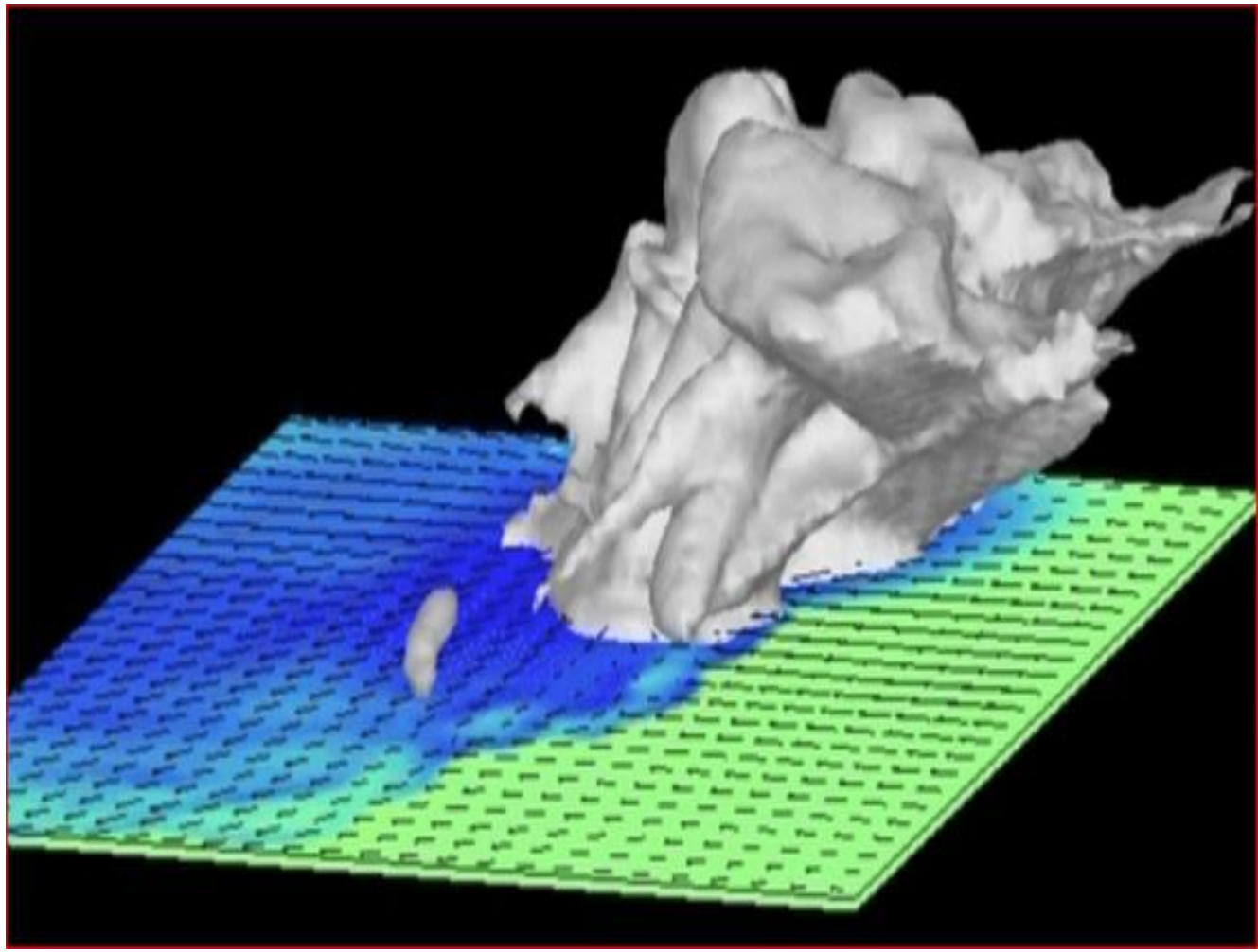


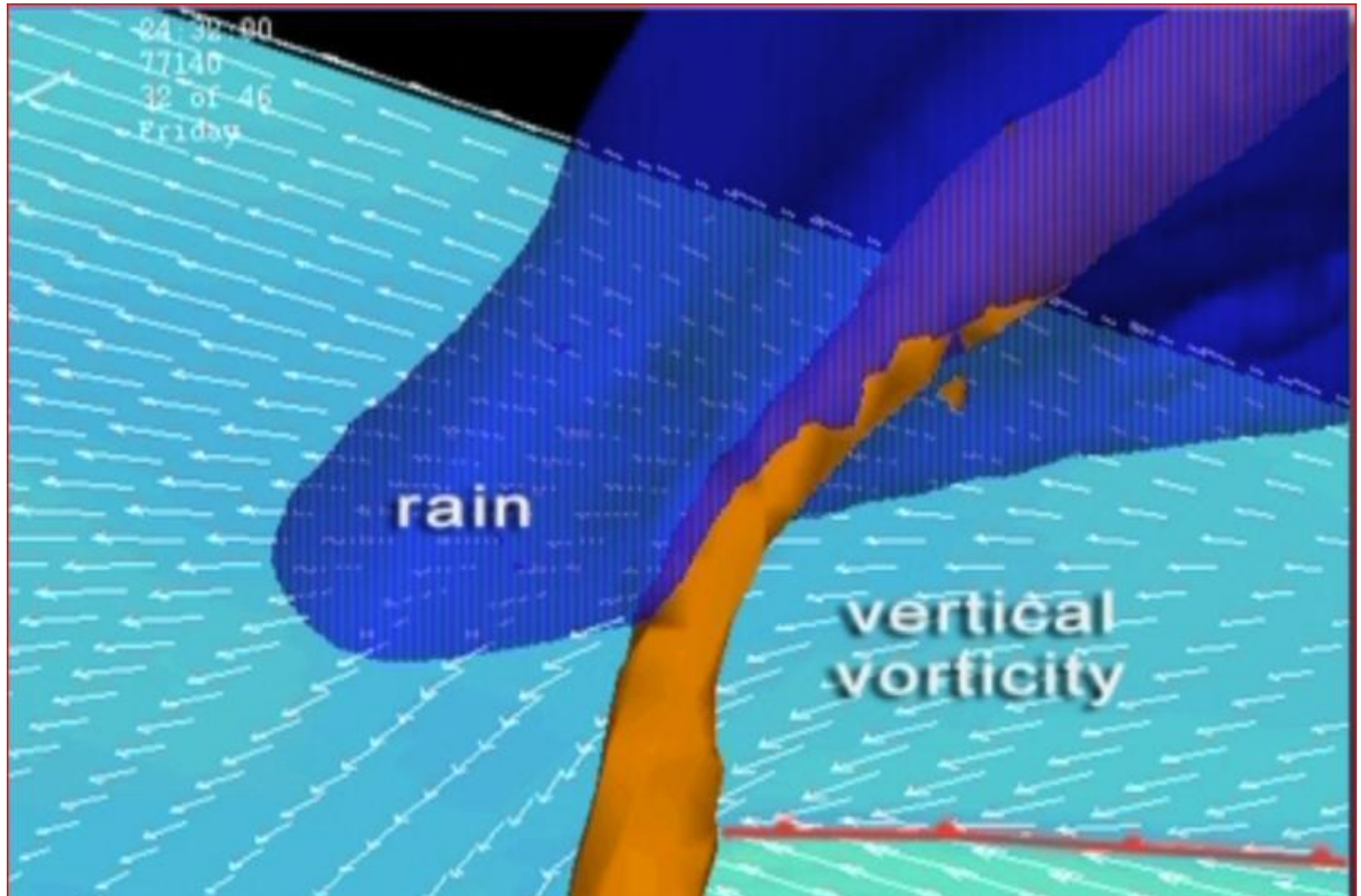
FFD: Forward front draft

RFD: rear front draft

Blue – areas of severe downdrafts



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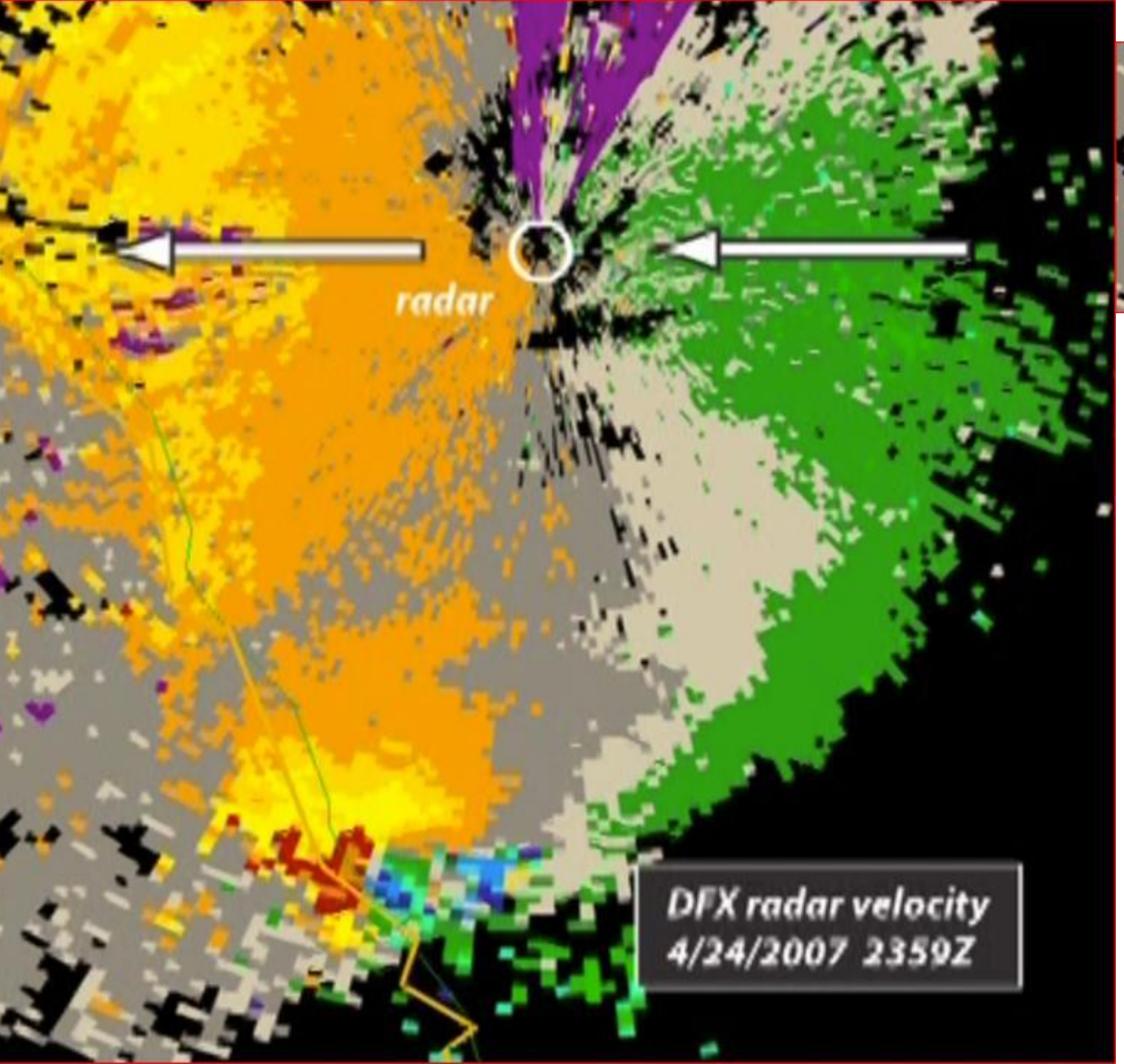
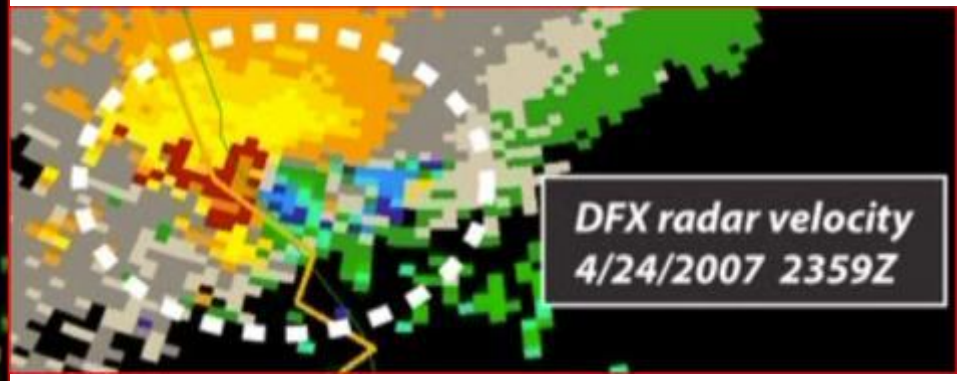
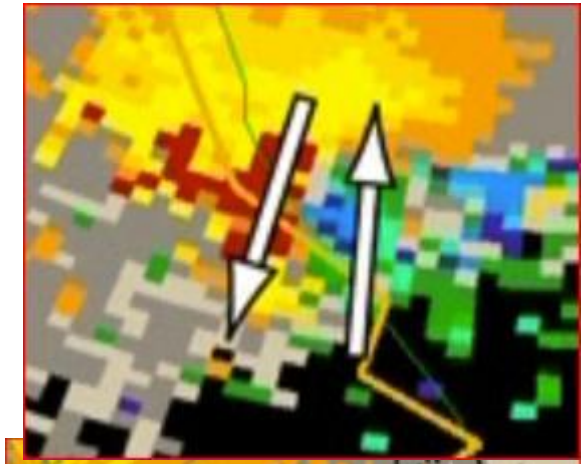
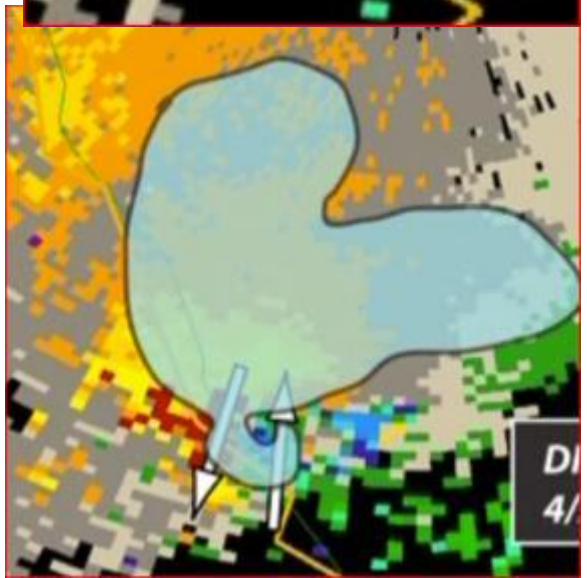
17140
32 of 46
Friday
rain
vertical
vorticity

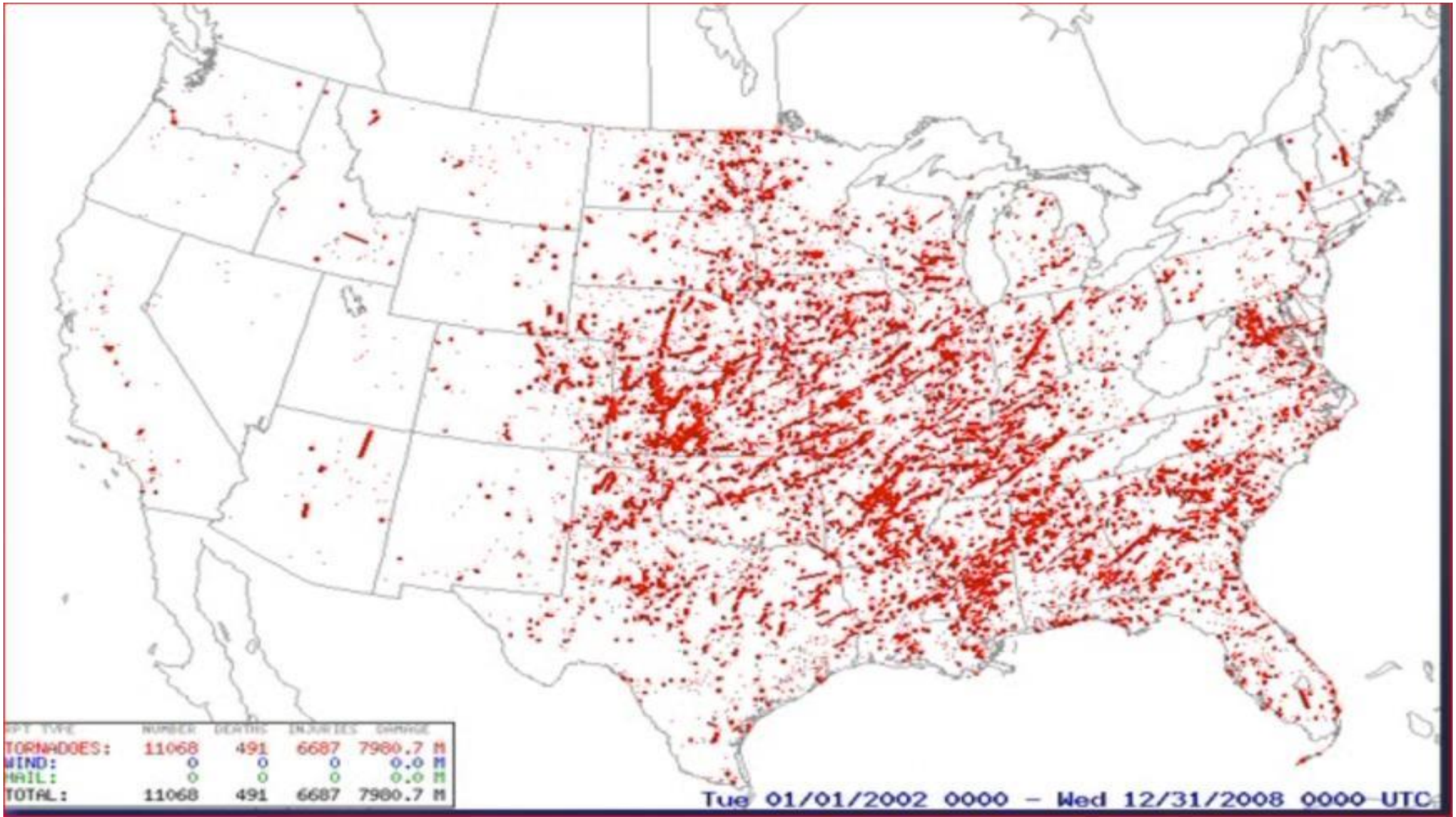

radar
DFX radar velocity
4/24/2007 2359Z


DFX radar velocity
4/24/2007 2359Z

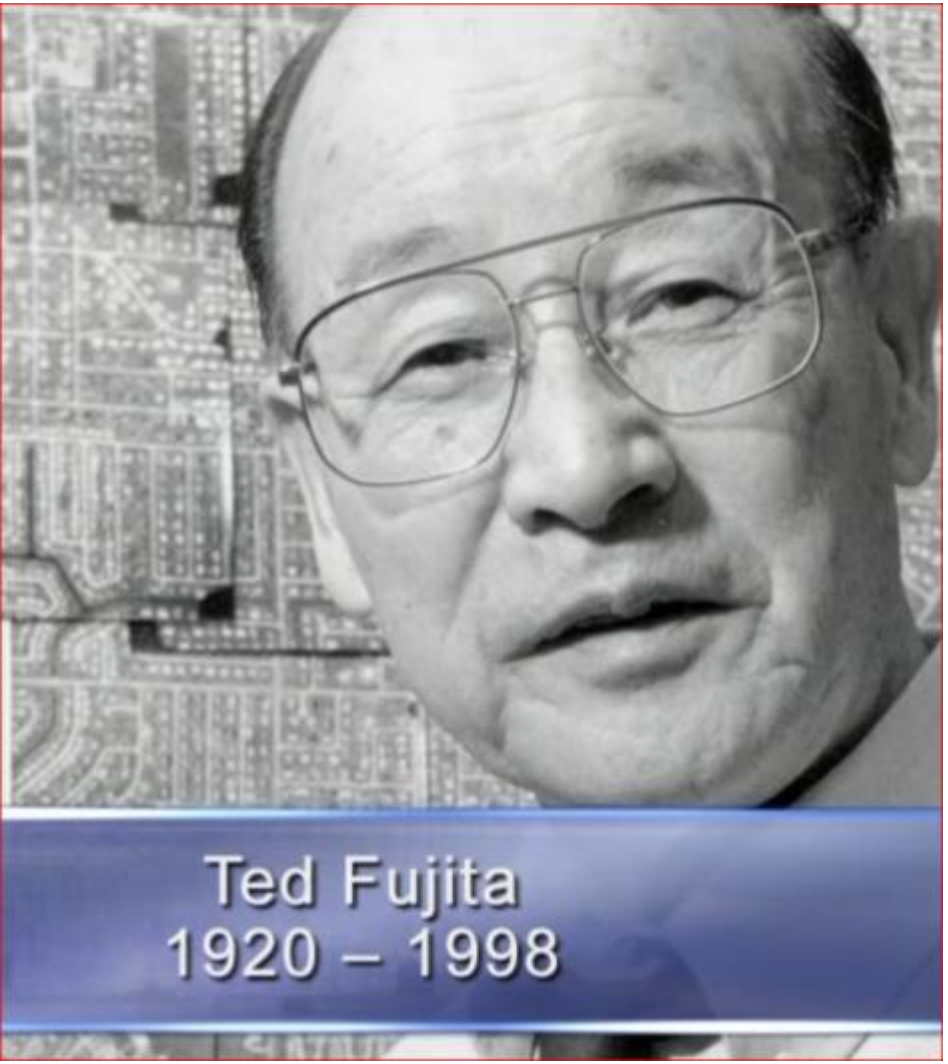




ALL tornadoes 2002 thru 2008; 11,000 plus



FUJITA SCALE: F0 THRU F5



Fujita Scale

F0: 40–72 mph / 64–116 km/h winds

F1: 73–112 mph / 117–180 km/h winds

F2: 113–157 mph / 181–253 km/h winds

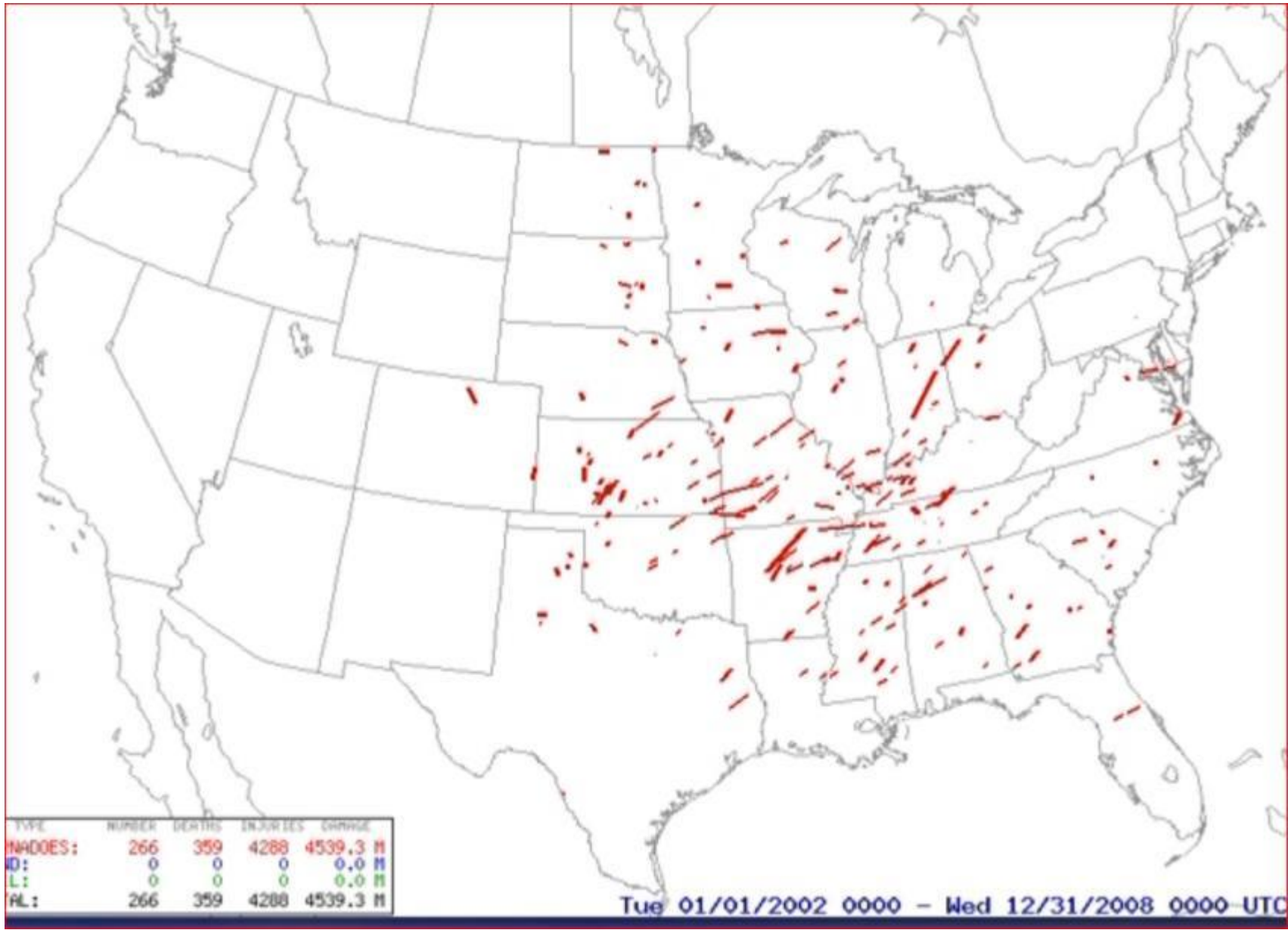
F3: 158–206 mph / 254–332 km/h winds

F4: 207–260 mph / 333–419 km/h winds

F5: 261–318 mph / 420–512 km/h winds

F3 THRU F5 TORNADOES ONLY

- ¾ of all deaths
- Tornadoes



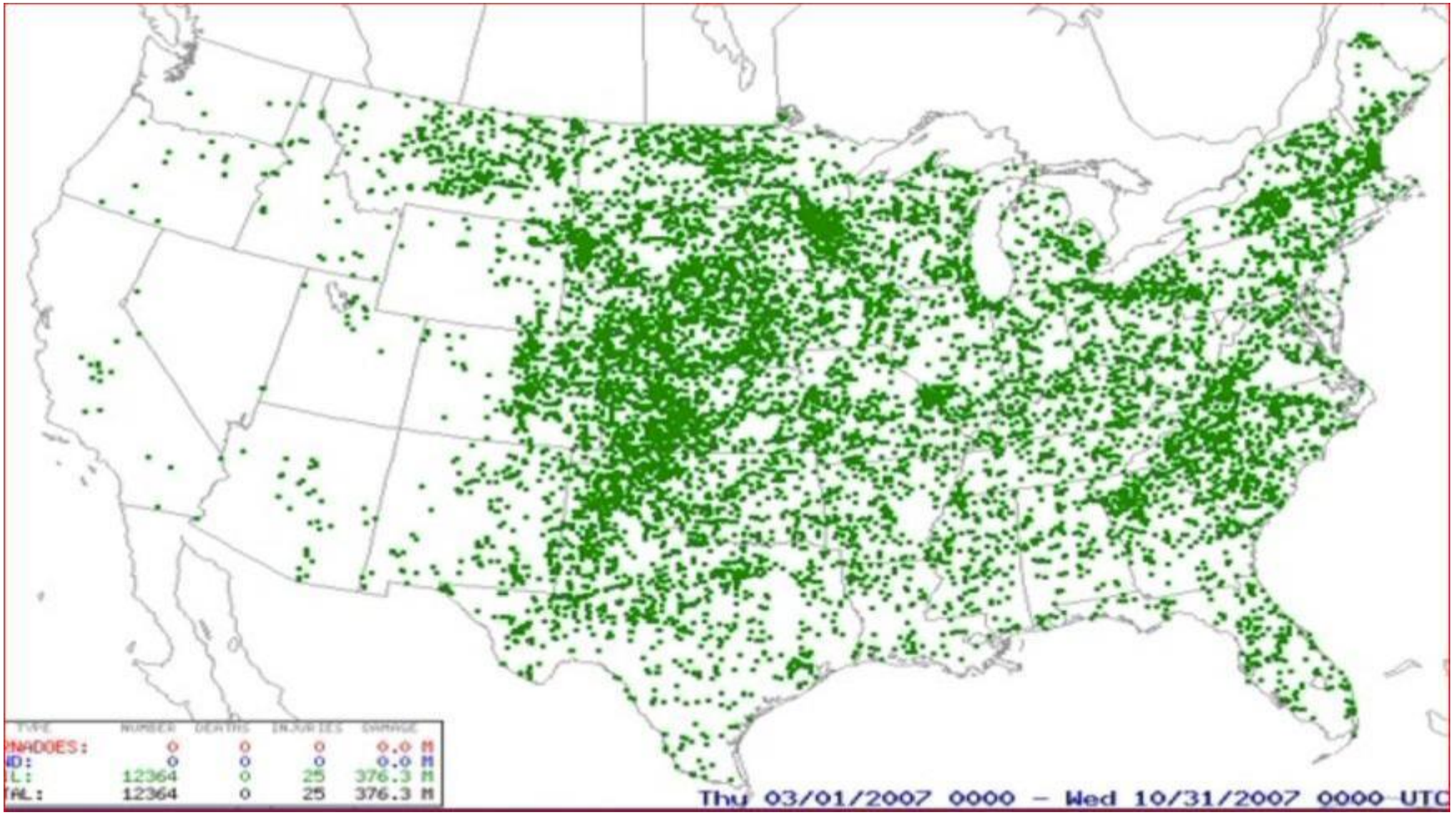
TORNADO FACTS

Quick Tornado Facts

- Tornadoes can last seconds to an hour.
- Tornadoes can occur in sequence.
- Tornadoes' color comes from condensation and debris.
- Fastest winds are over 300 mph.

WALL CLOUD

8 MONTHS of large hail (>.75”)



SUMMARY

- The intense rotating SUPERCELL rotation results from taking large vertical rotation and converting to horizontal spin cells– opposing each other (one clockwise and the other counterclockwise) – looks like a split
- Most tornadoes observed to have counterclockwise rotation

Next topic – ocean influence and then hurricanes

- END OF WEEK 6