ATM S 103

Hurricanes and Thunderstorms

Their Science and Impacts

Midterm 1: Wednesday May 1

- Bring a Scantron form
- Closed book, notes, electronics
- 30 multiple choice questions (similar to homework)
- Covers
  - Homework 1-3 (you can get a paper copy of HW problems/answers from TA, send her an email: kanglt@uw.edu)
  - Lectures through April 24
  - Reading weeks 1-4

Divine Wind History Readings

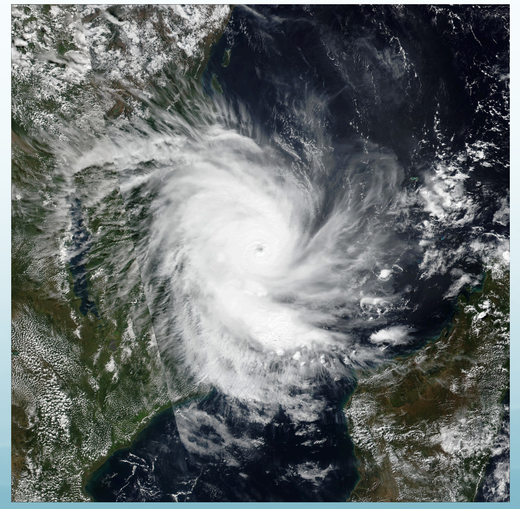
- Japan, 1274/1281: “Divine Wind” storms that stopped Mongol invasion
- Etymology of hurricane/cyclone/typhoon
- Columbus’s hurricane of 1502
- Florida storm of 1565: thwarted French invasion
- *The Tempest*, 1609: lost ship ends up colonizing Bermuda
- Hurricanes of 1780: includes deadliest ever in Western Hemisphere
- Galveston, 1900: deadliest in US

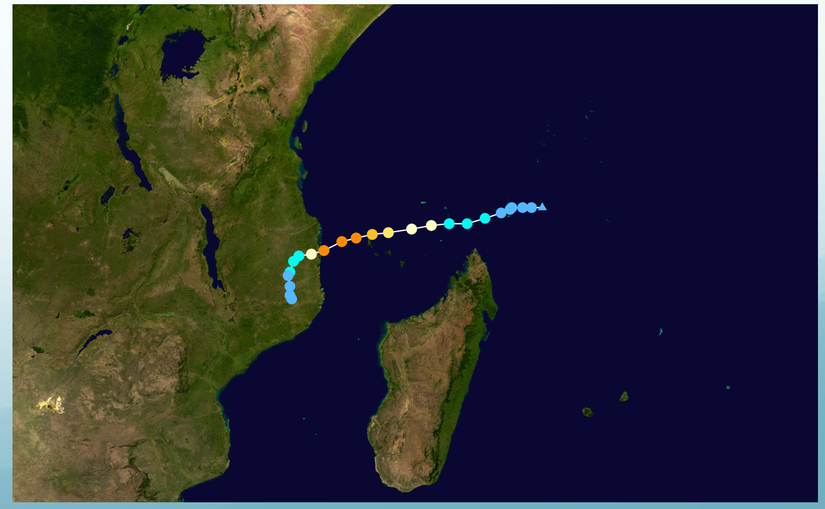
Do you have questions?

- I'll be out of town from Tuesday until Sunday
  - No office hours this week
  - E-mail response would be slow
- Litai
  - Office hour Today 1:30-2:30pm and Tomorrow 1:30-2:30 PM 406 ATG
  - Email for another time (kanglt@uw.edu)

Kenneth update II

- https://www.cbsnews.com/news/cyclone-kenneth-mozambique-death-toll-flooding-today-live-updates-2019-04-29/
- Over 30,000 people evacuated
- At least 45 people lost their lives





Topics for today

- Multi-cell thunderstorms
- Supercell thunderstorms
- Weather radar

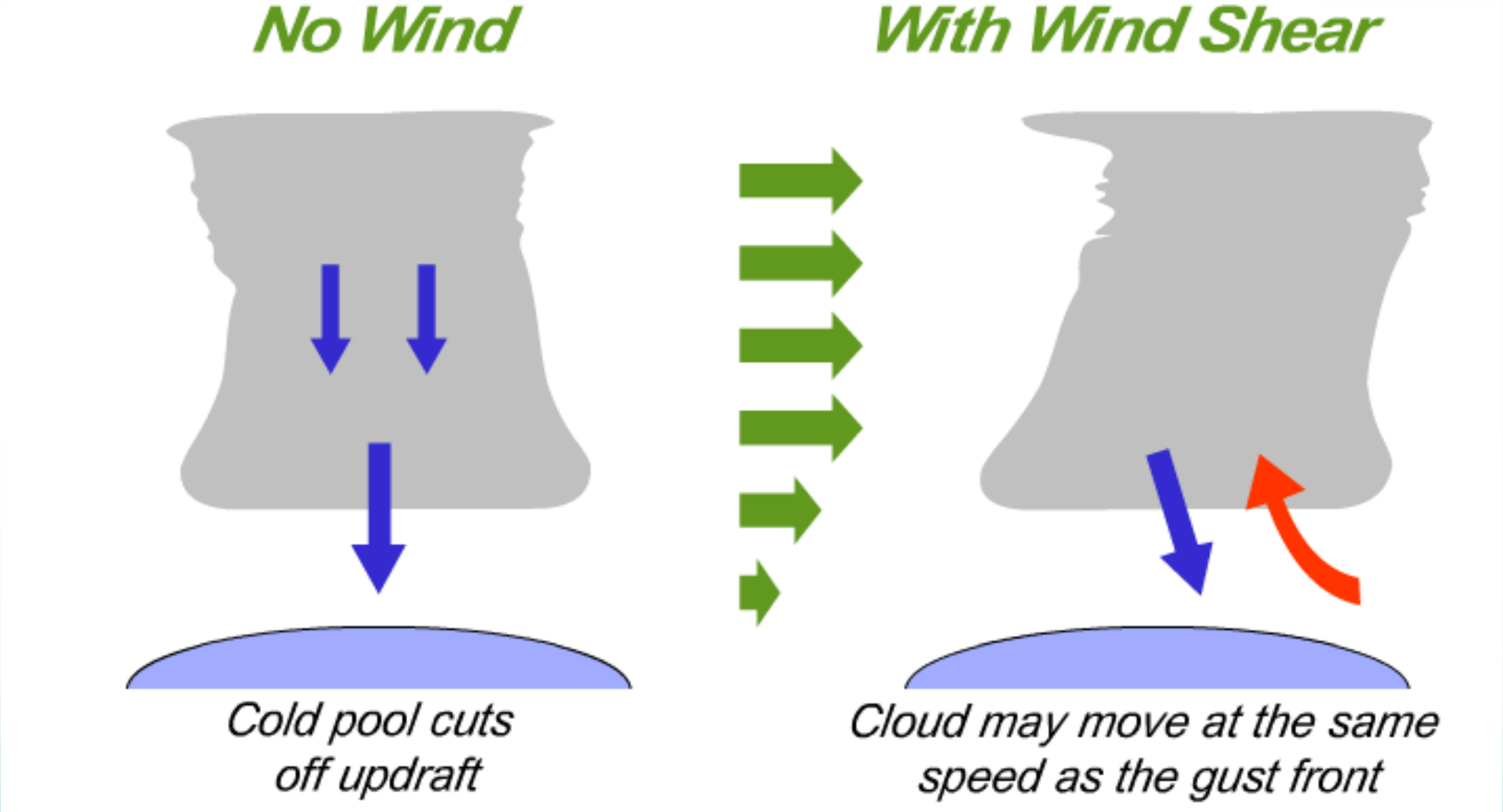
Type of Thunderstorm Is Determined By

- How much warmer rising air parcels become in comparison to their environment (the CAPE)
- The change with height in the wind speed and direction in the lowest 5 km of the atmosphere.
  - This is the low-level wind shear.

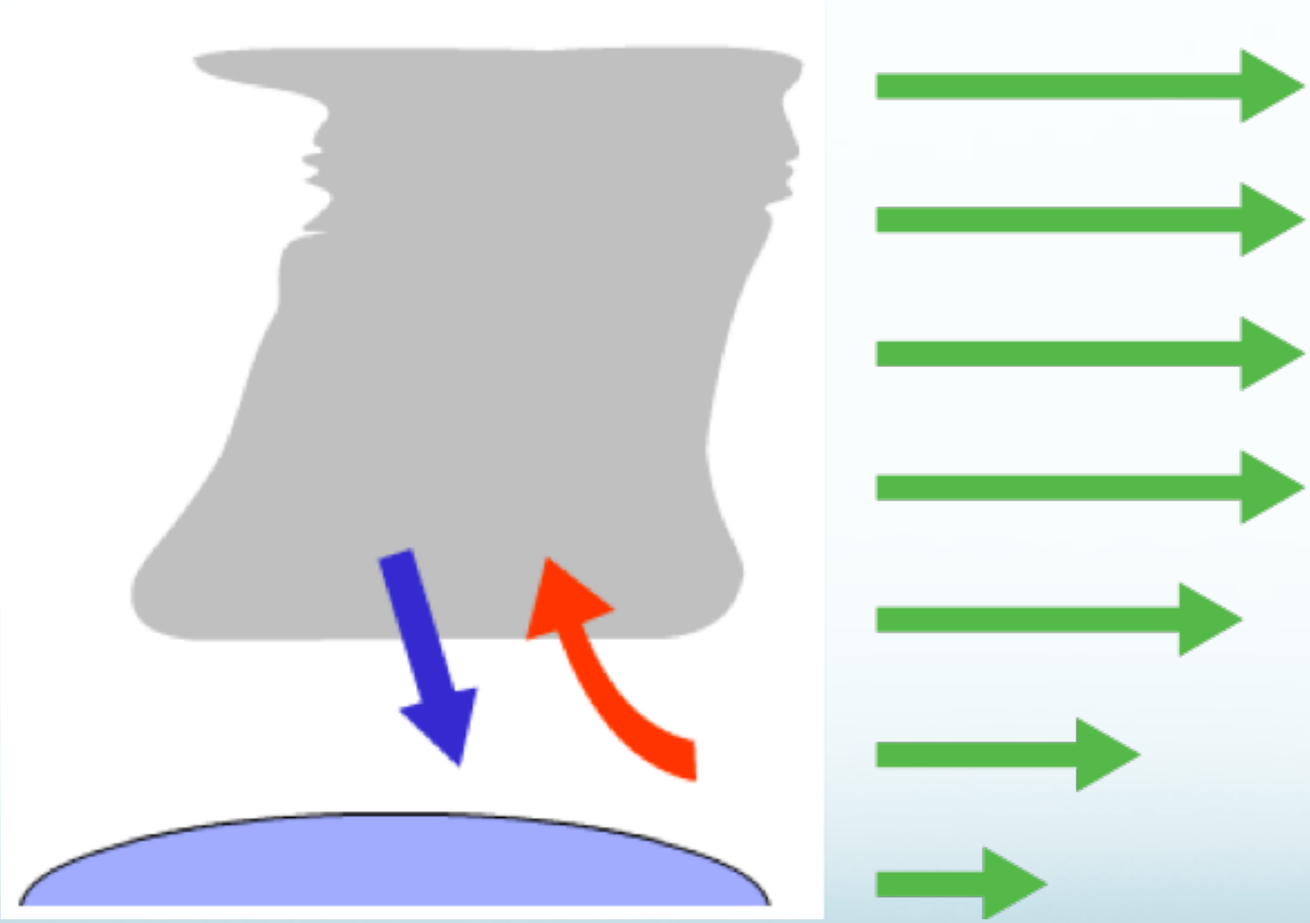
Extending the Lifetime Beyond that of a Single Cell Storm

- Need to keep the cold pool/gust front from cutting off the updraft.
- This can be accomplished by low-level wind shear.

Influence of Low-Level Wind Shear

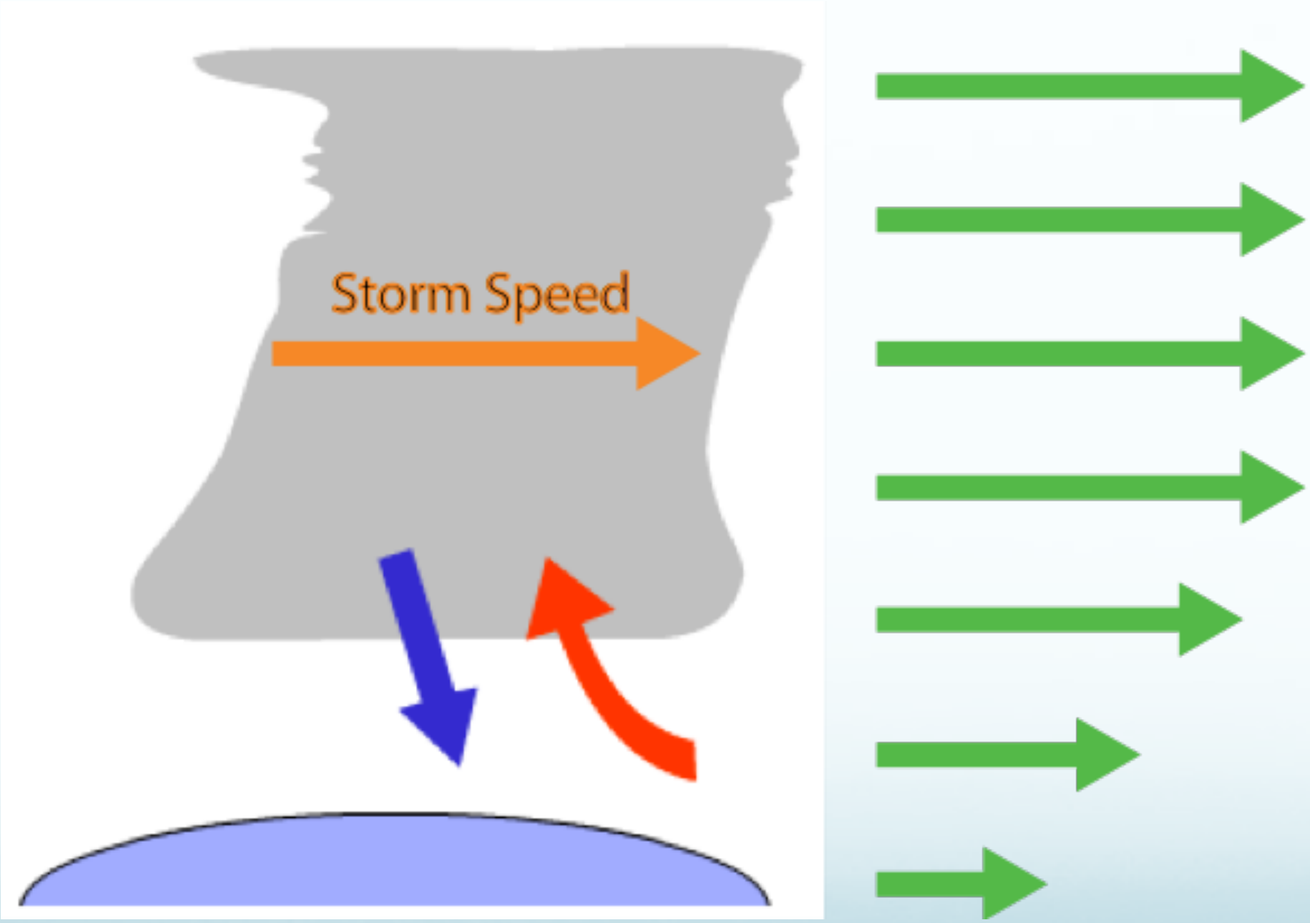


Environment with Low-Level Shear



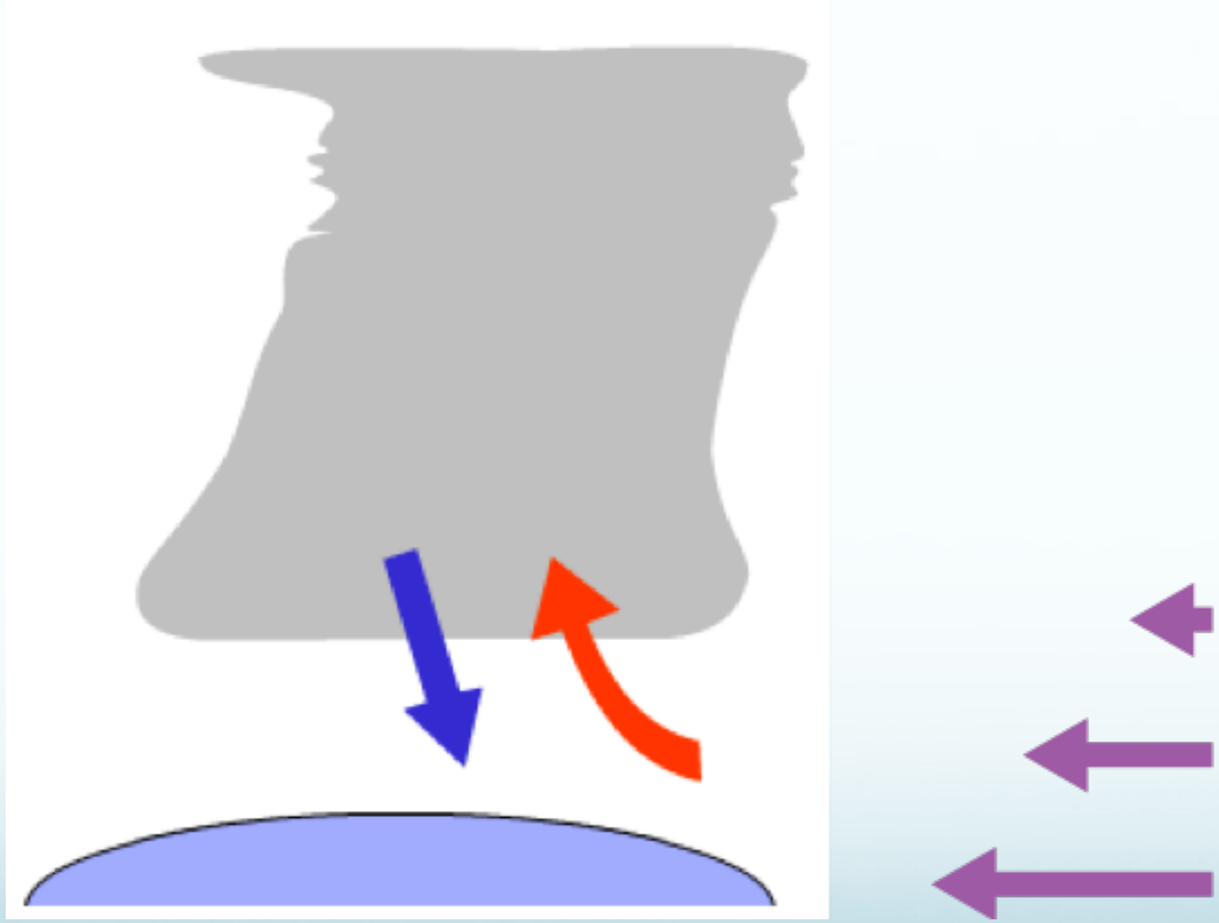
Shift to Storm-Relative View Point

Subtract (remove) the storm speed from the environmental winds.



Storm-Relative Winds

Low-level shear holds back the gust front.

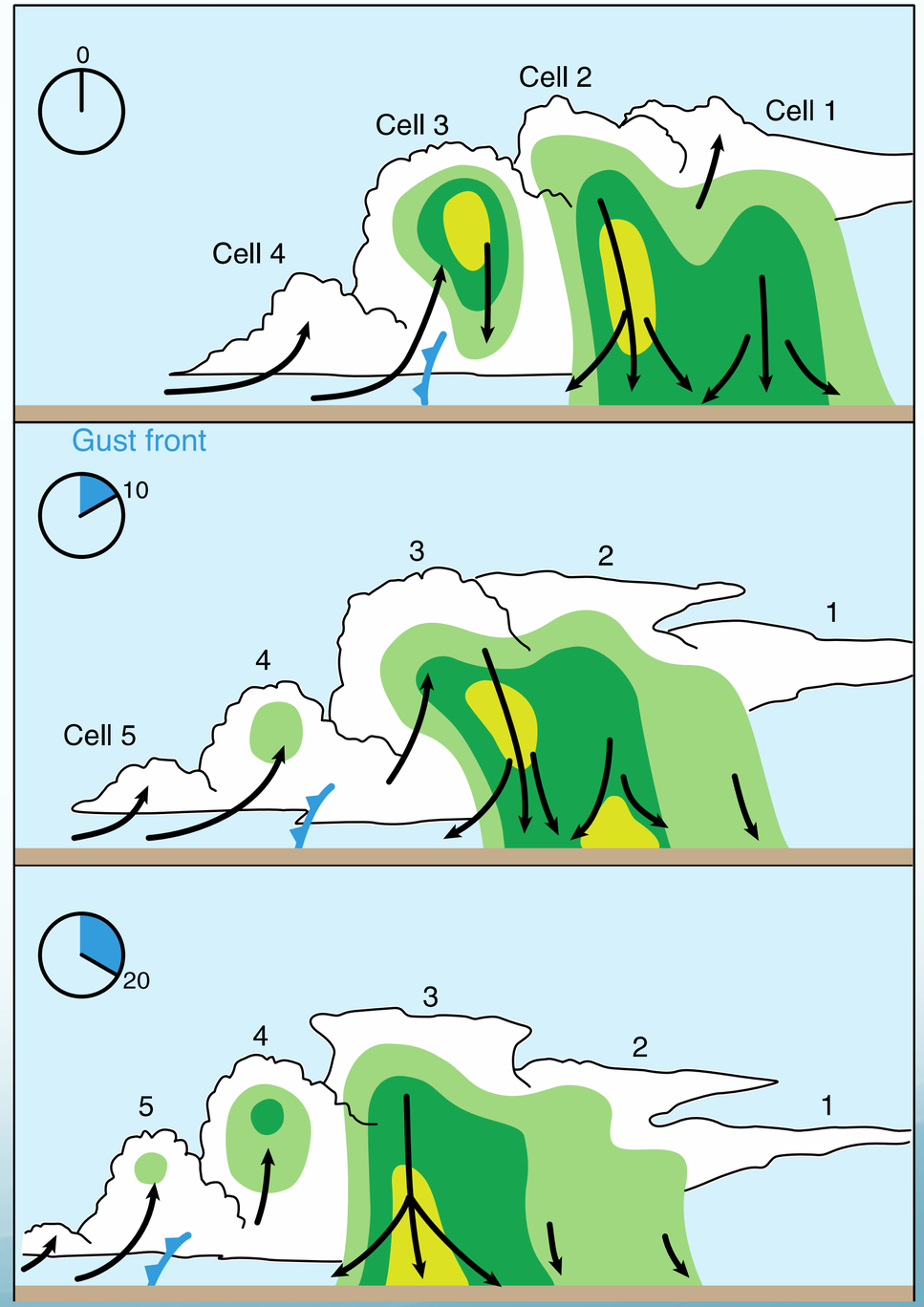


Influence of wind shear on thunderstorm structure

- Single cell (weak low-level wind shear)
  - “Ordinary” or “air mass” thunderstorm
  - Generates lightning.
- Multi-cell (moderate low-level wind shear)
  - May be severe (>1” hail, winds > 58 mph)
  - Seldom makes strong tornadoes
- Supercell (strong low-level wind shear)
  - Relatively long-lived
  - Associated with most strong tornadoes

Multi-cell Thunderstorm

Multi-cell Schematic



Multi-cell storms last longer than single-cells because

There is more CAPE, i.e., more energy available to power the storm.

Low-level wind shear keeps the cold pool from surging out to cutoff the updraft.

The surface temperatures and dew points are higher.

Answer

- Multi-cell storms live longer because low-level wind shear keeps the cold pool from surging out to cutoff the updraft

Time Lapse of a Multi-Cell T-Storm

Storm in action

At sunset

Supercell Thunderstorms

- Account for almost all
  - Instances of hail > 2” diameter
  - Violent tornadoes (>111 mph gusts)
  - High lightning flash rates (up to about 200 per min)
- Long-lived
  - 1– 4 hours common
  - As long as 8 hours

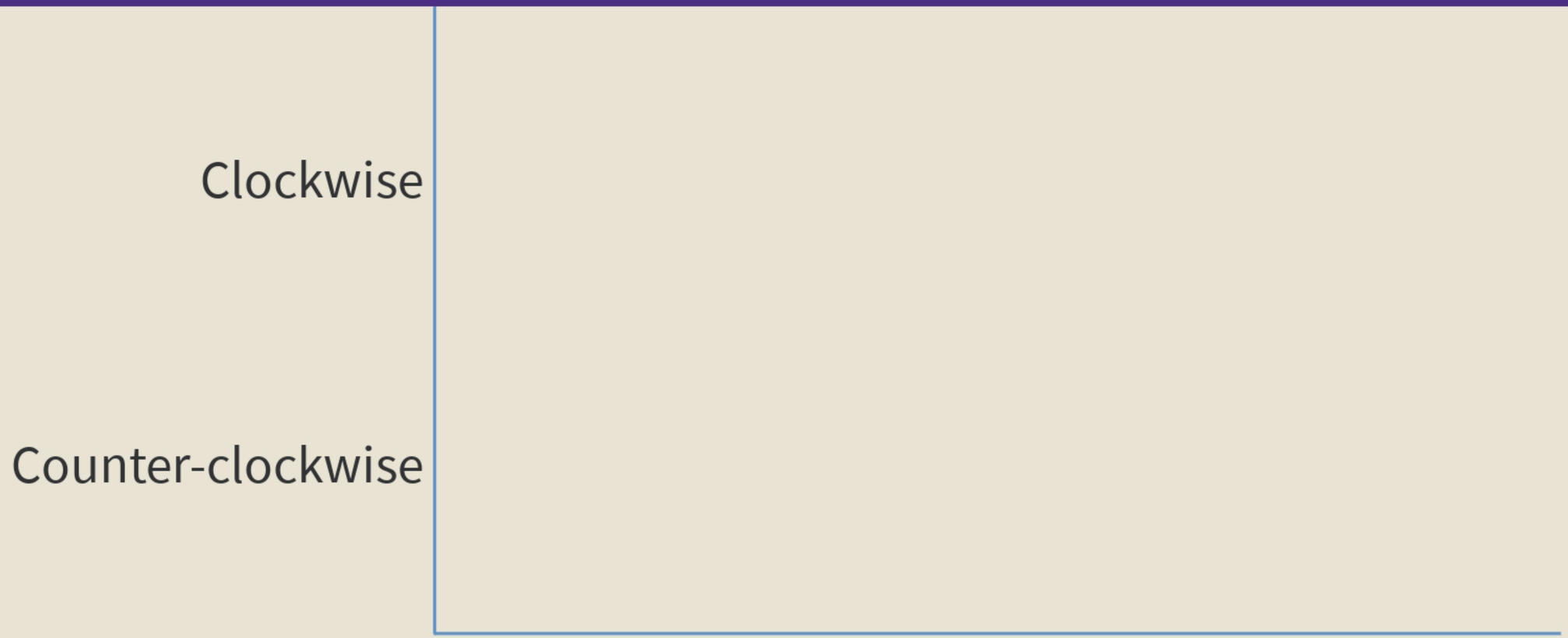
Distinguishing Property of Supercells

Significant rotation in the updraft throughout at least half the depth of the storm

Leoti, Kansas: May 21, 2016

Near the updraft

Which way, as viewed from above, does the cloud appear to rotate?



Start the presentation to see live content. Still no live content? Install the app or get help at **PollEv.com/app**

Total Results

Answer: counterclockwise

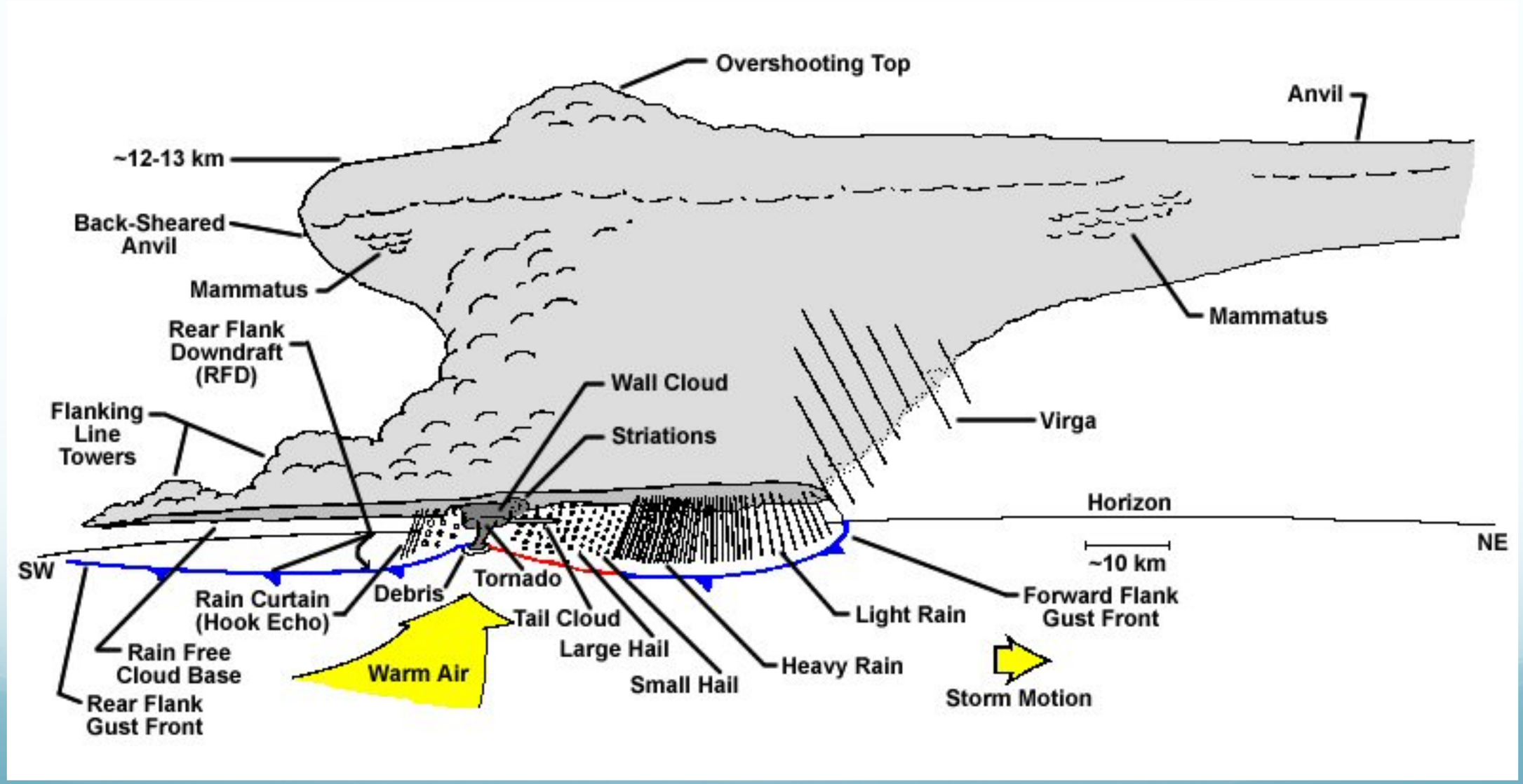
Supercell Updraft and Downdraft

Smoke from grass fire

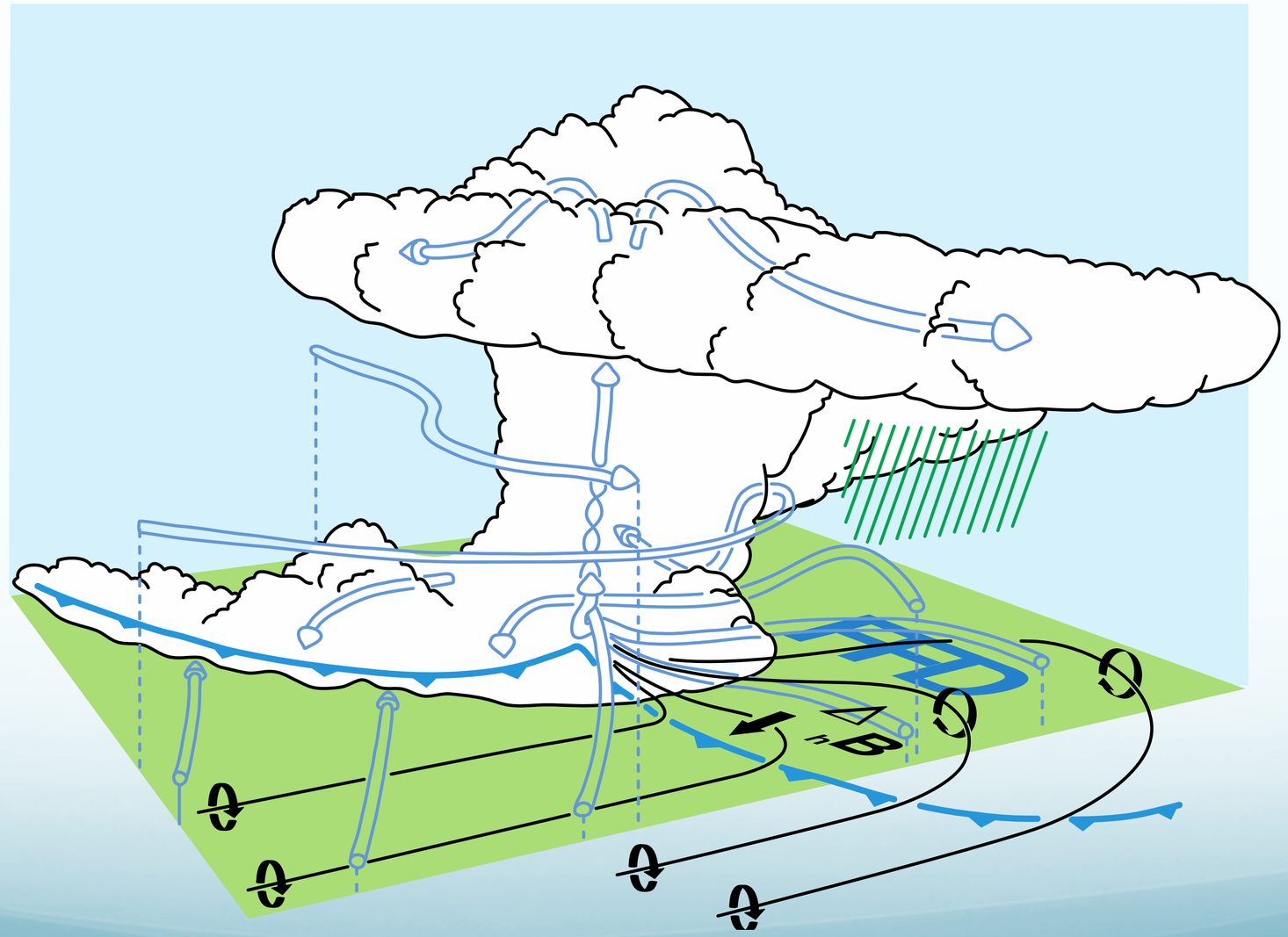
Observations

- Air that is not obviously buoyant is being sucked up into the updraft.
- Lots of rotation (counterclockwise), but no obvious tornado.
- The most exciting action is in a relatively small part of the storm.

Supercell Thunderstorm



Storm-Relative Flow (Open Arrows)



What's Special About Supercell Environments?

- Decent but not unusually large CAPE (Convective Available Potential Energy)
  - Parcels that rise far enough, saturate and become warmer than their environment.
  - But the amount of CAPE is not necessarily higher than for multi-cell storms.
- *Wind shear is strong* and is significant through a much deeper layer than for multi-cells.

Vertical Wind Shear and Supercells

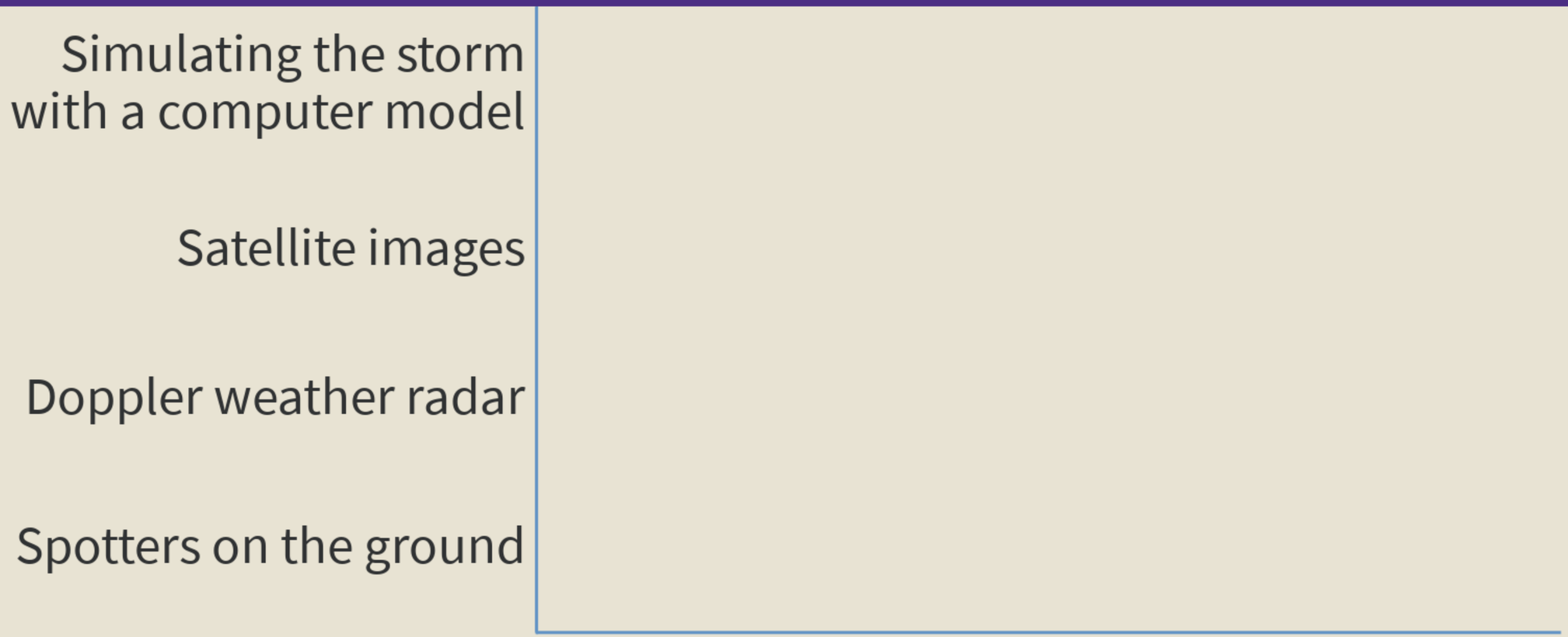
- Low-level wind shear still helps separate the rain and the updrafts (as in multi-cells)
- The deep-layer wind shear
  - Also helps to move the precipitation away from the updraft in a 3-dimensional sense
  - Interacts with the updrafts to produce important pressure variations throughout the storm.

Vertical Wind Shear and Supercells

Deep-layer wind shear interacts with the thunderstorm to:

- Add upward directed pressure forces to the updraft
  - Upward force is not exclusively due to buoyancy of warm air rising.
- Make the storm move at an angle to the deep-layer-average wind direction

What is the most important tool for figuring out whether a thunderstorm is a supercell?



Start the presentation to see live content. Still no live content? Install the app or get help at **PollEv.com/app**

Total Results

Answer: Doppler radar

Weather Radar

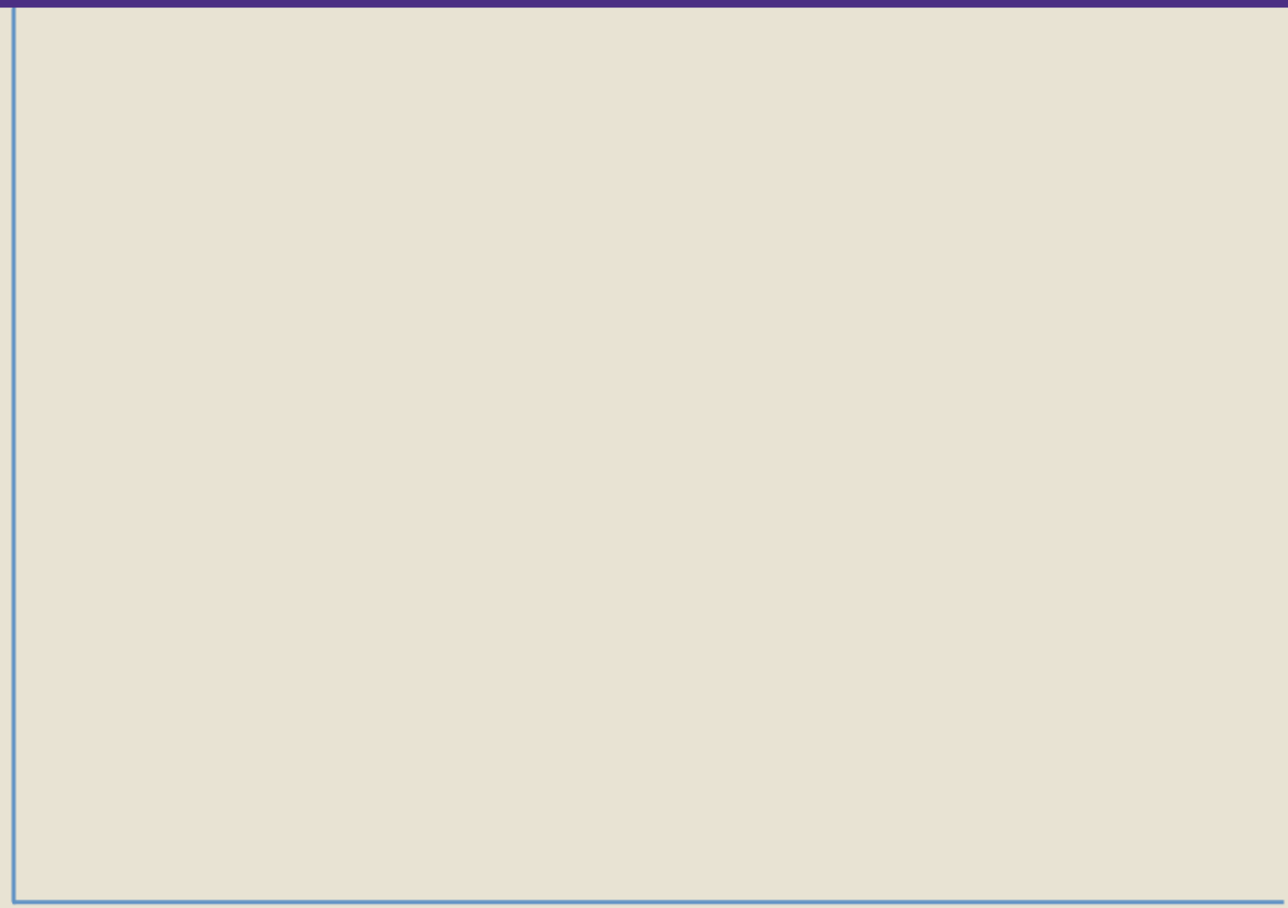
- Used extensively to observe and analyze many types of weather.
- Key tool in identifying and studying supercells

(Langley Hill radar on Washington Coast)

Radar Fundamentals

- Radar sends out pulses and listens for the “reflection” of those pulses off the “target”.
- Weather radar: targets are?

Weather radar "targets" include

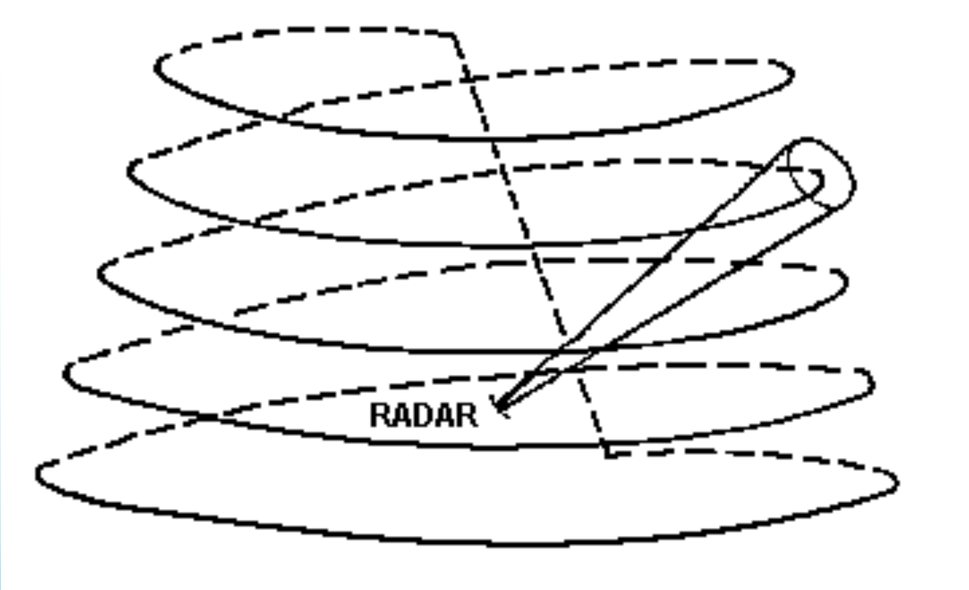


Correct: All of the above

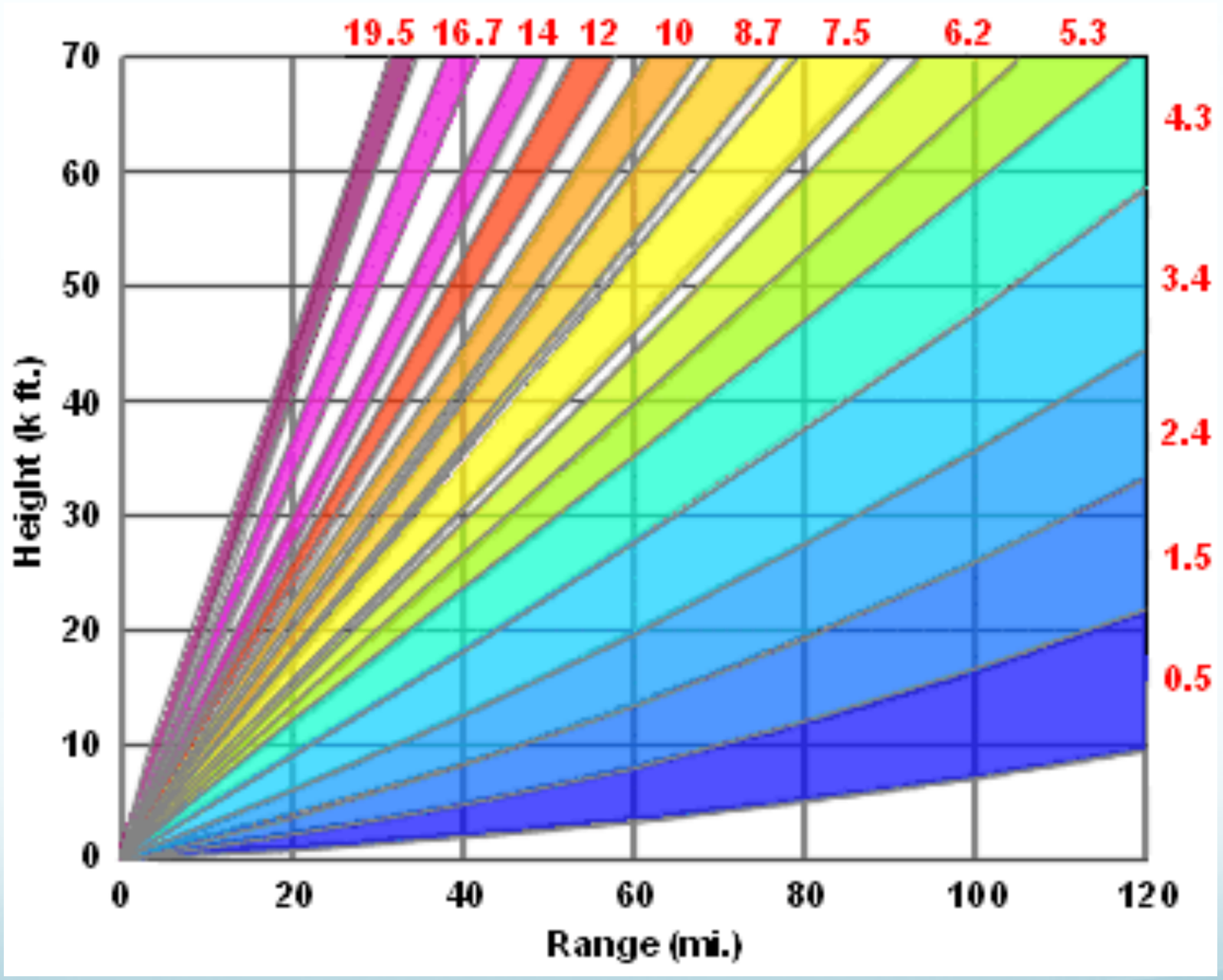
- Buildings and mountains are ground clutter (and often removed)
- Insects can provide useful information
- Birds are a distraction

Reflectivity

- Strength of the signal scattered back to the radar increases rapidly with droplet diameter.
  - Stronger returns from bigger drops.
- Scanning strategy: NWS radar network



Radar Elevation Angles & Beamwidth

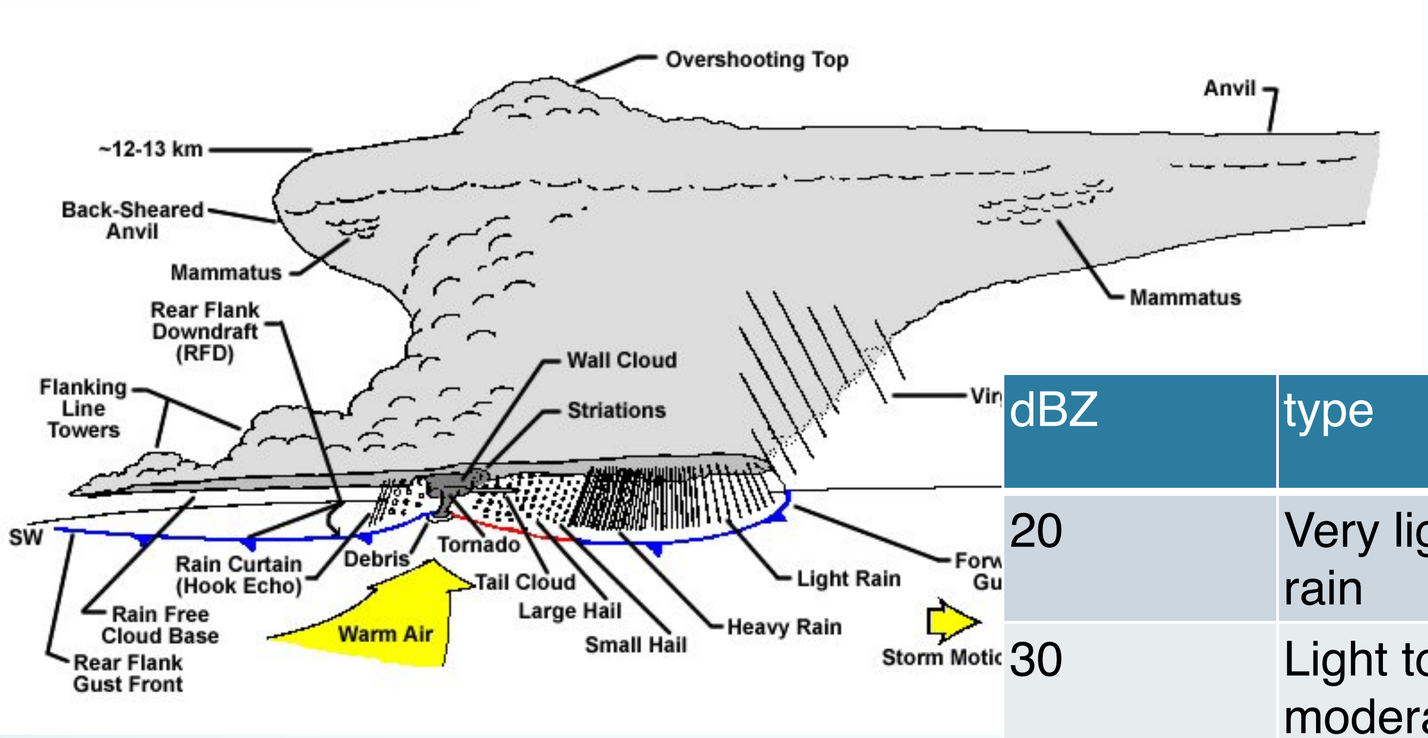


5 minutes required to perform the 14 conical scans

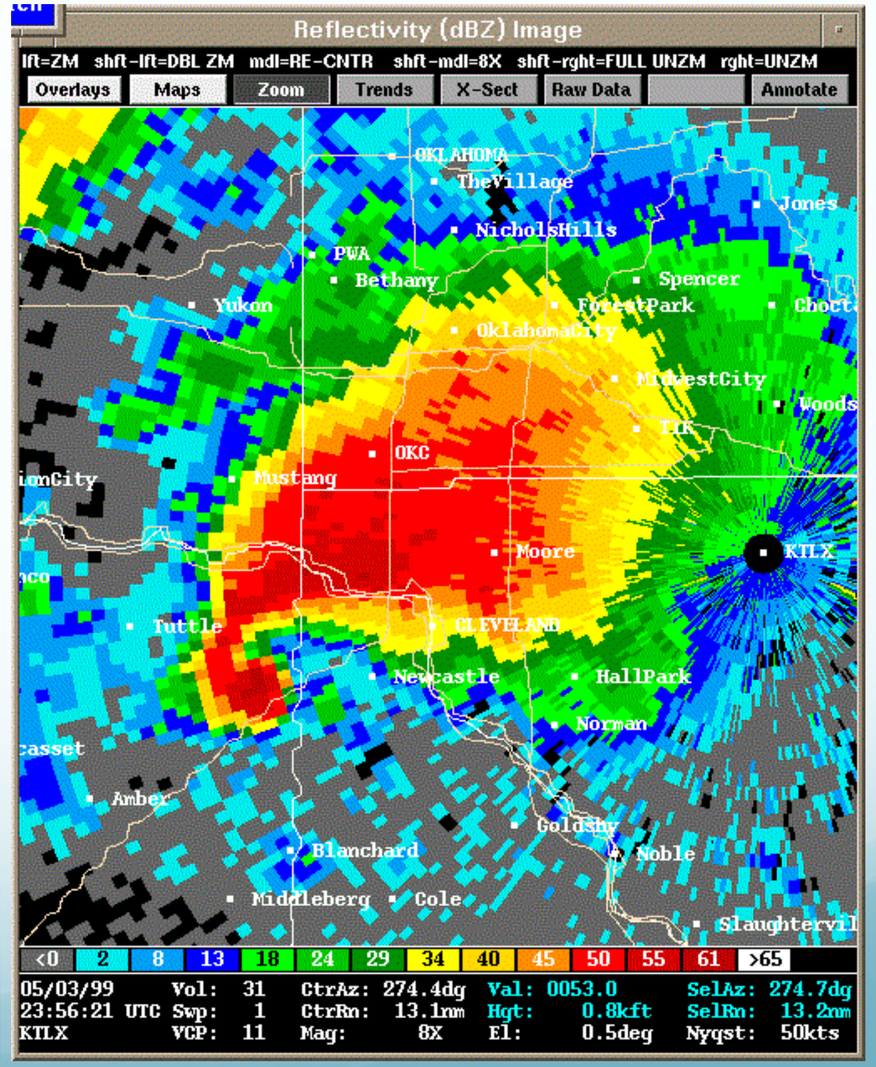
Weather radar scanning pattern

- Animation

Radar Reflectivity for a Supercell



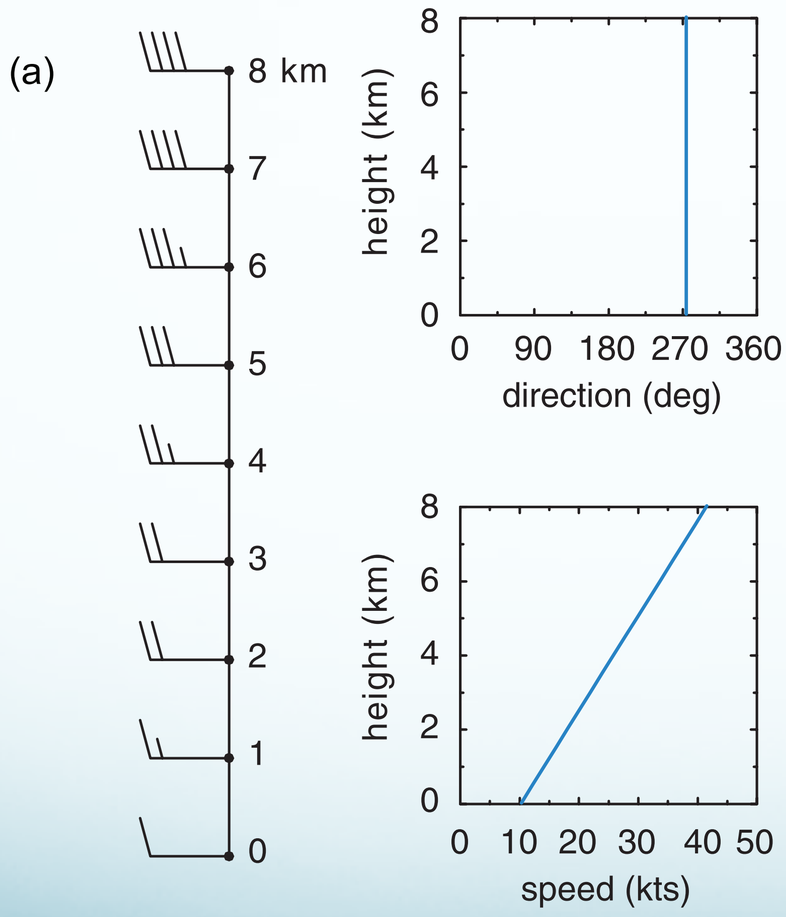
dBZ	type
20	Very light rain
30	Light to moderate
40	Moderate rain
50	Heavy rain
60	Moderate hail

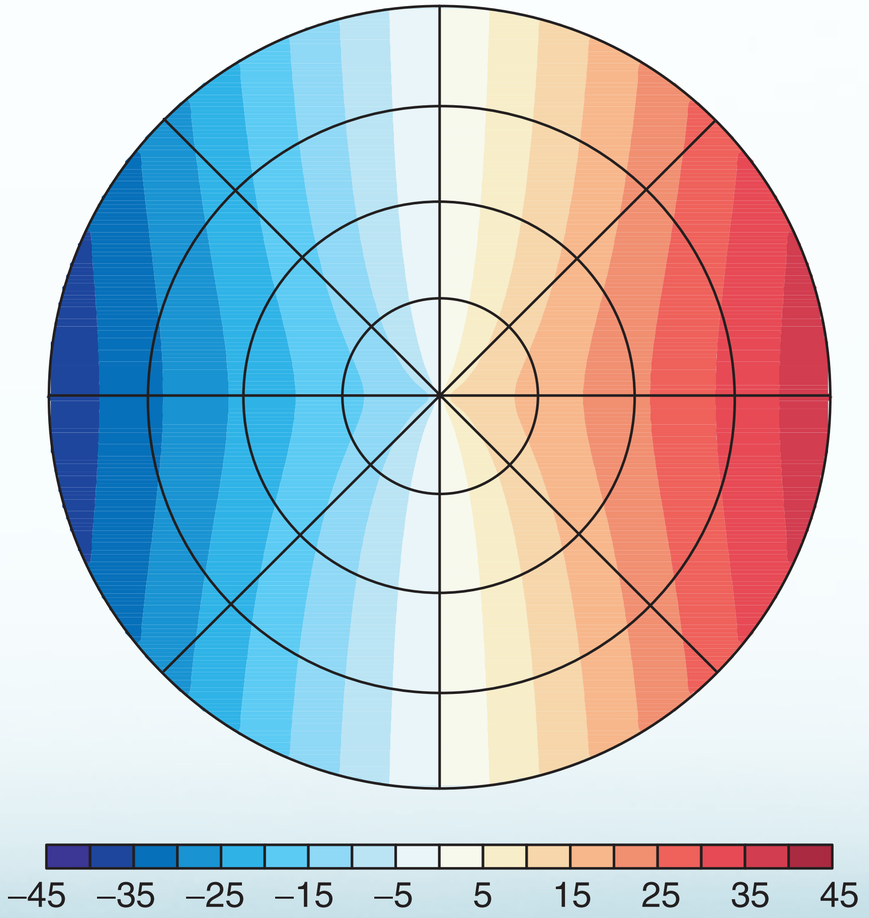


Velocity Data

- Obtained from the change in the signal reflected back to the radar between two consecutive pulses.
- Very complicated to understand for most realistic cases, so it's almost never shown on TV.
- Exception: the velocity signature associated with strong rotating supercell updrafts.
  - "Easy" to understand
  - Is shown on TV in tornado prone areas.

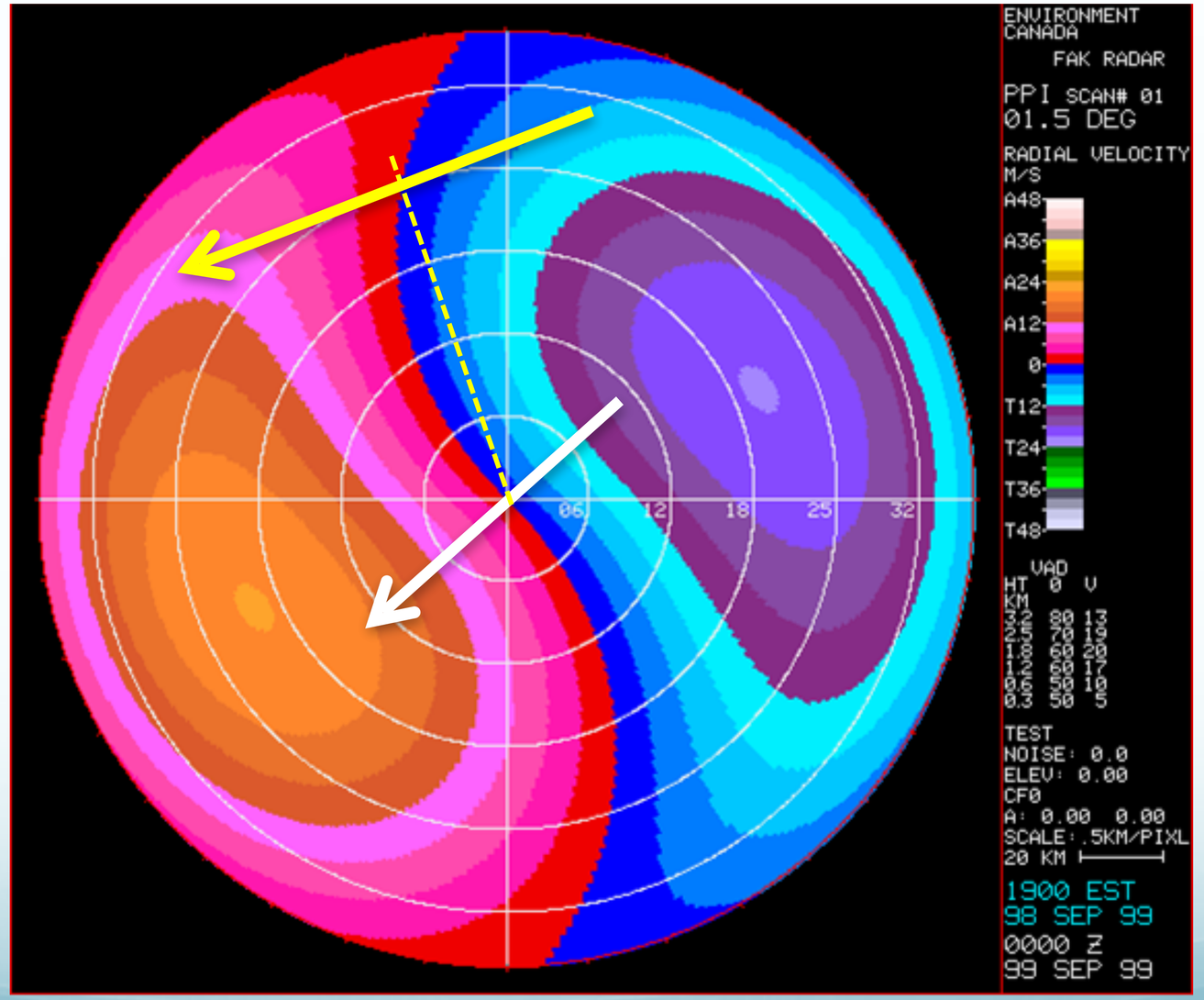
Doppler radar velocity display: winds increase with height, no turning



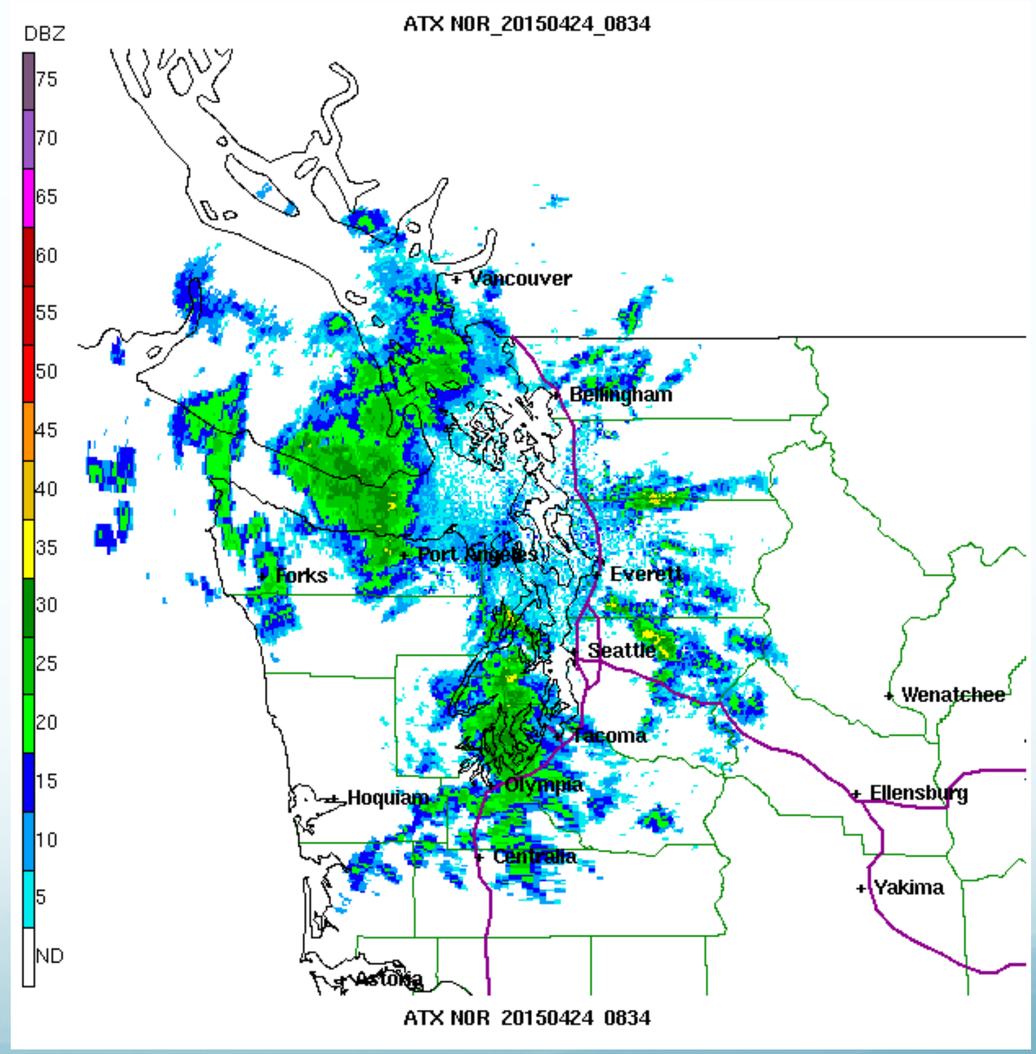


Blue: toward the radar
Red: away from the radar

Doppler radar velocity display: winds turn with height



Camano Island radar: Reflectivity



Camano Island radar: Doppler velocity