MET 4300

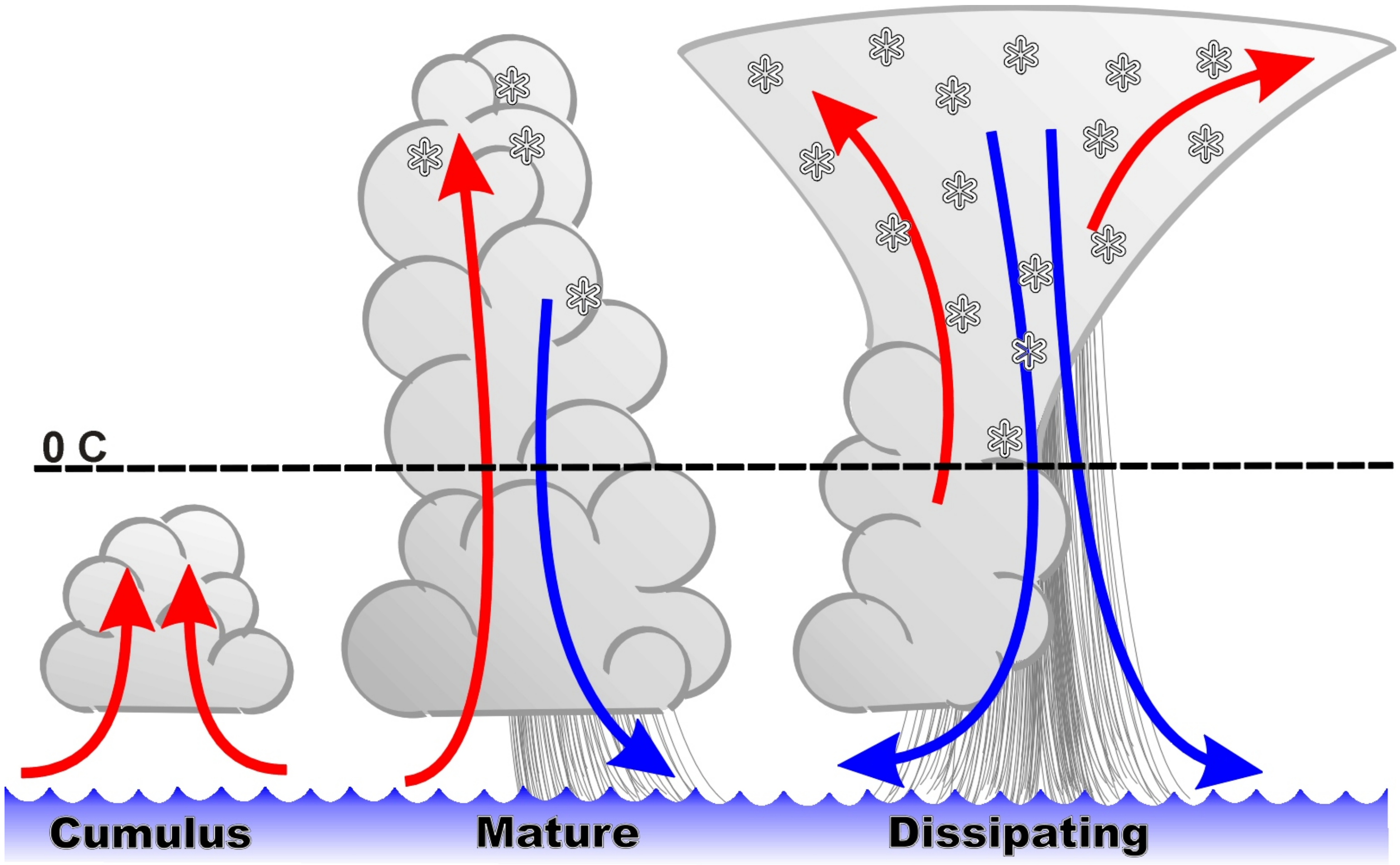
Lecture 20

Frontal Squall Lines (CH18)

Convection Depends Upon the Storm Environemnt

- Thermodynamic Stability
- Vertical wind Profile
- Mesoscale Forcing
- Pre-storm conditions hint at convective evolution, at least for isolated, fairly simple systems
- Three types,
  - Single Cell (**Airmass thunderstorm**)
  - Multicell: **frontal squall line** and **MCS** (including MCC, non-frontal squall line, or organized cluster)
  - **Supercell**

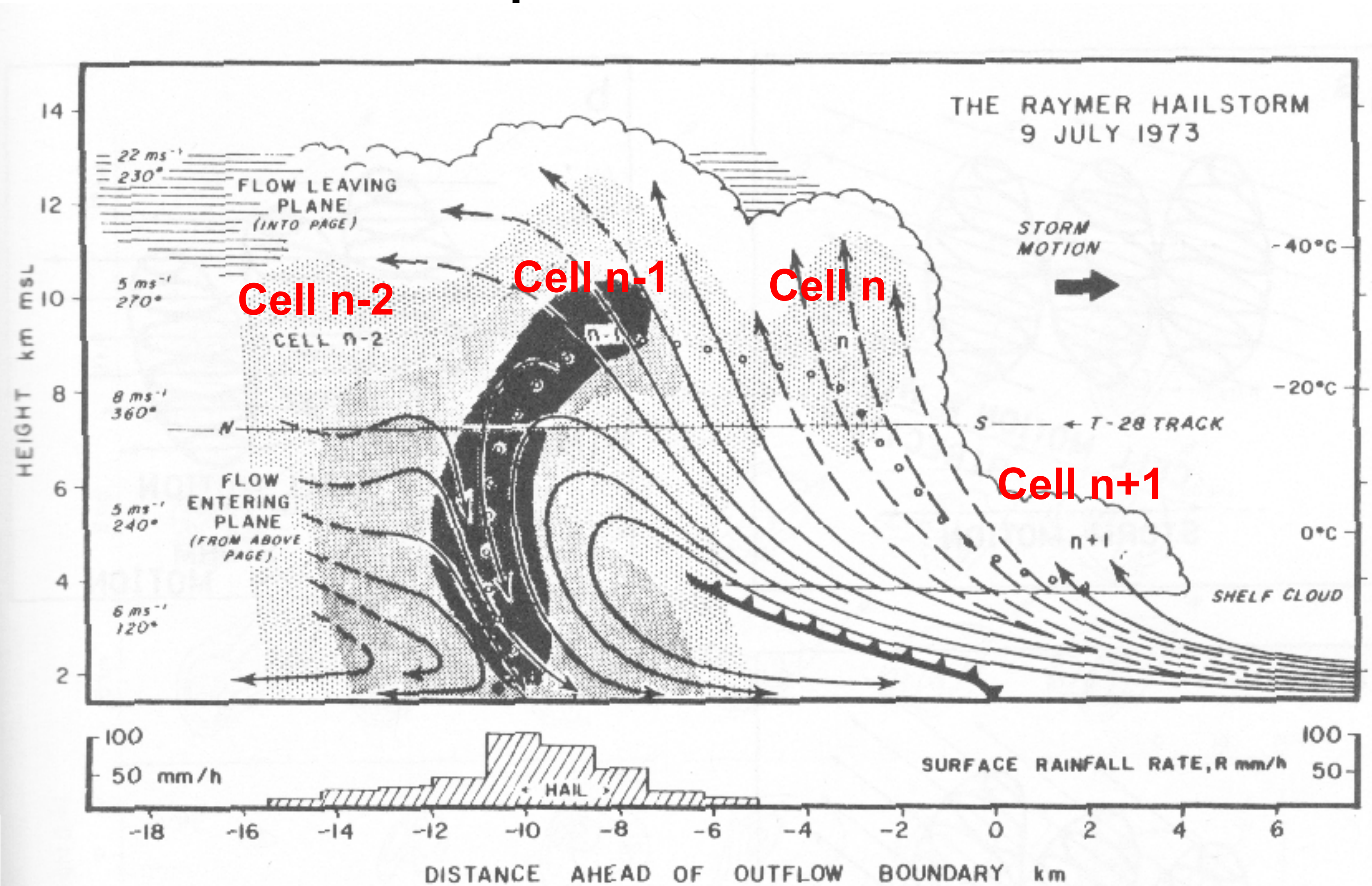
Air-Mass Cumulus Life Cycle



Multicell Storm

- An organized cluster of single cell storms
- Outflows combine to form an extensive gust front
- Convergence along the leading edge
- Triggers new updrafts along and just behind the outflow boundary
- Tends to occur along a preferred (often right) flank of the storm
- Cell motion (more or less with the wind) differs from that of the storm as a whole
- Can produce heavy rain, hail, even the occasional weak tornado.
- Slow <u>storm</u> motion (Training) can cause nasty floods

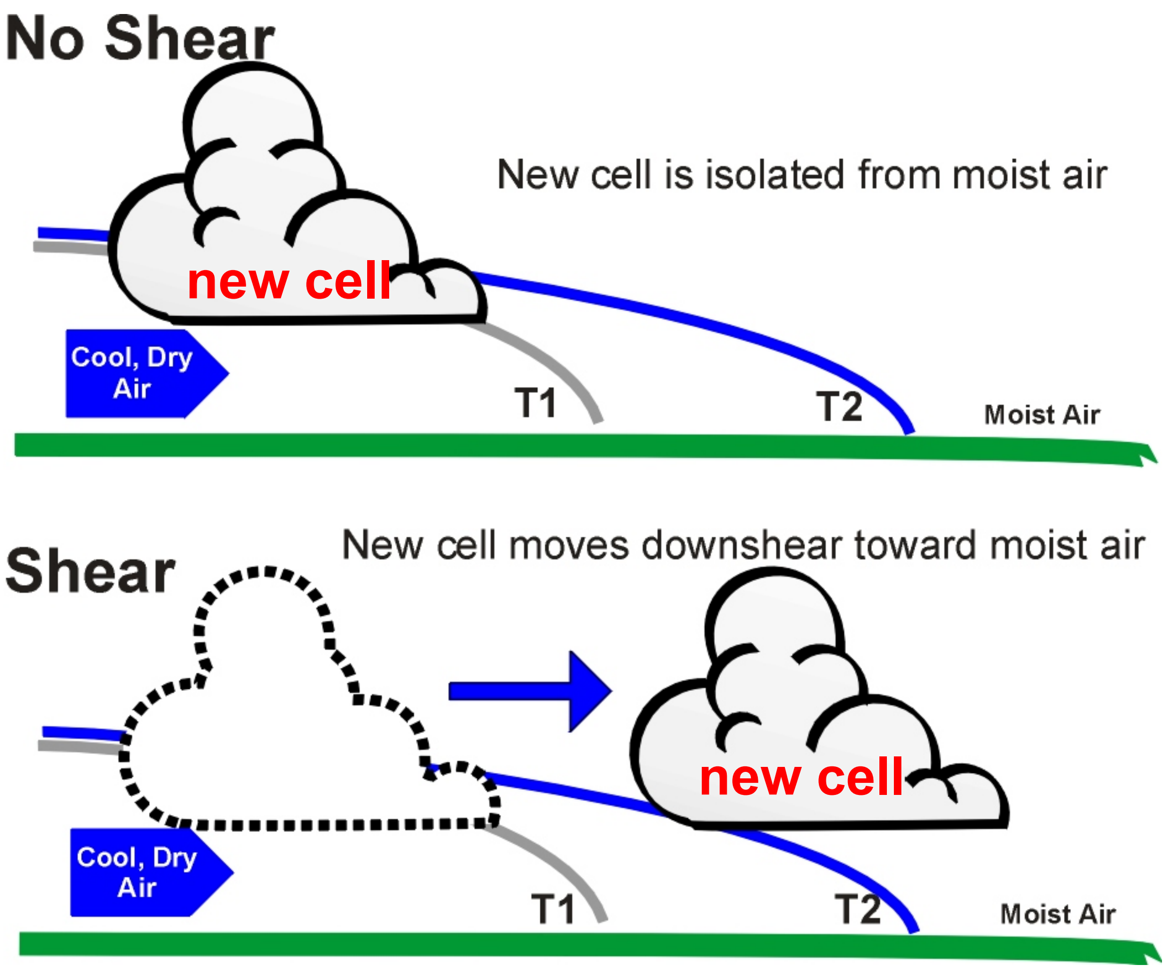
For Example in Multicell Storms



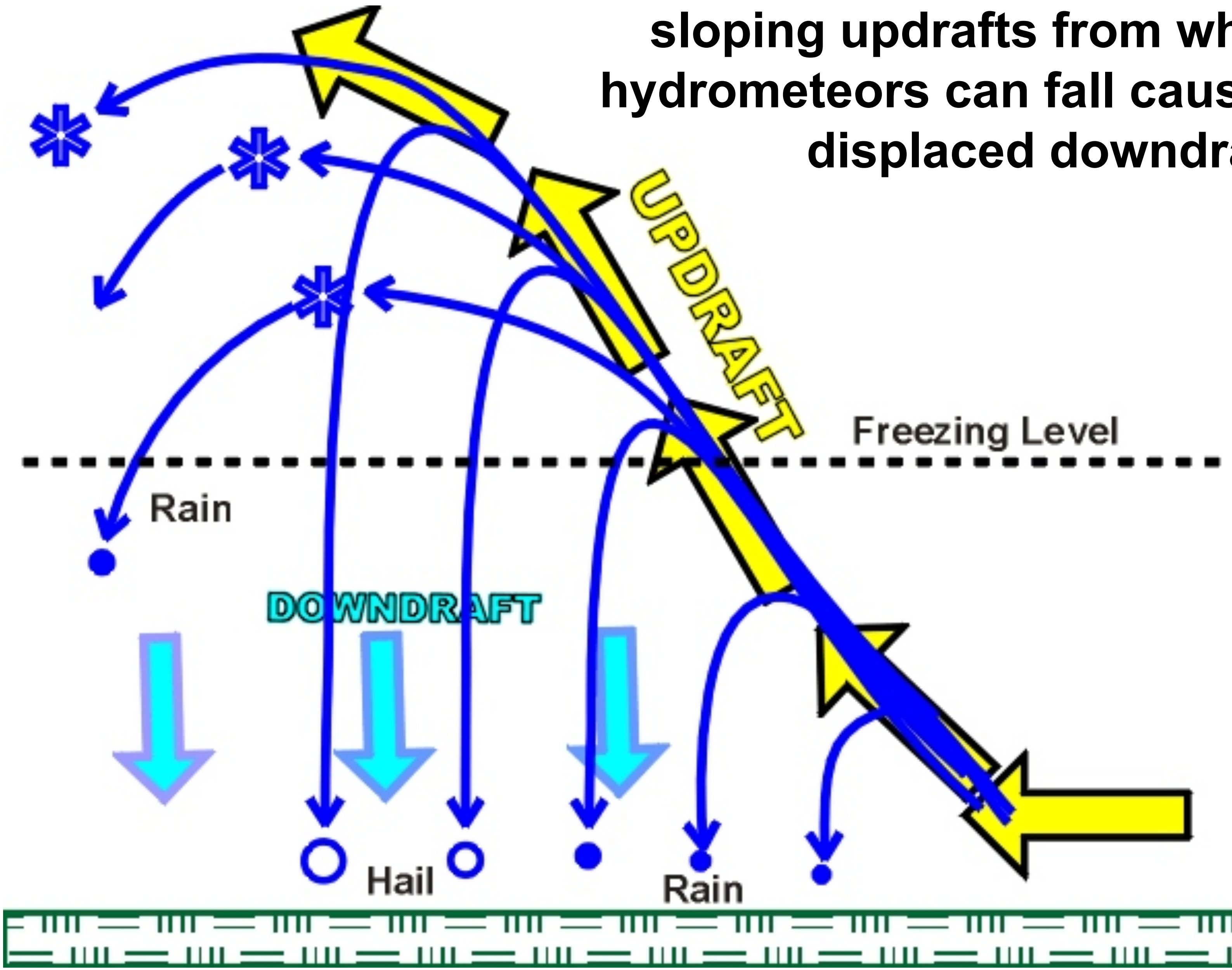
Vertical Shear

- Difference in wind speed and/or direction in the lowest 6 km (for these purposes) V(6km) – V(0.5 km)
- Organizes convection in two ways:
  – Helps the gust front to trigger new cells
  – Helps updraft to interact with vertical shear to produce a steady updraft.

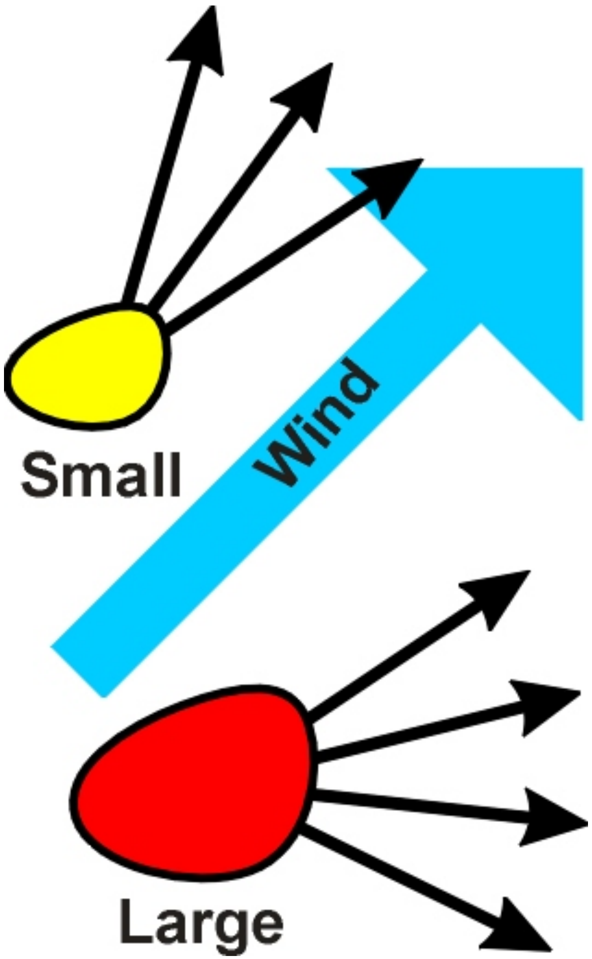
Shear and new cell formation along outflow boundaries



Shear and cell motion produce sloping updrafts from which hydrometeors can fall causing displaced downdrafts



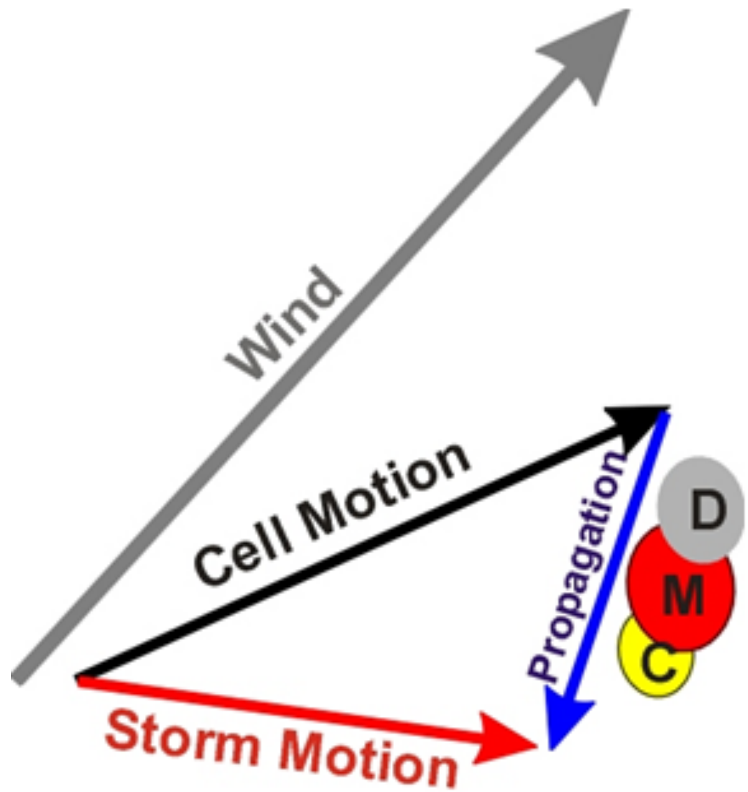
Motion of Individual Cells



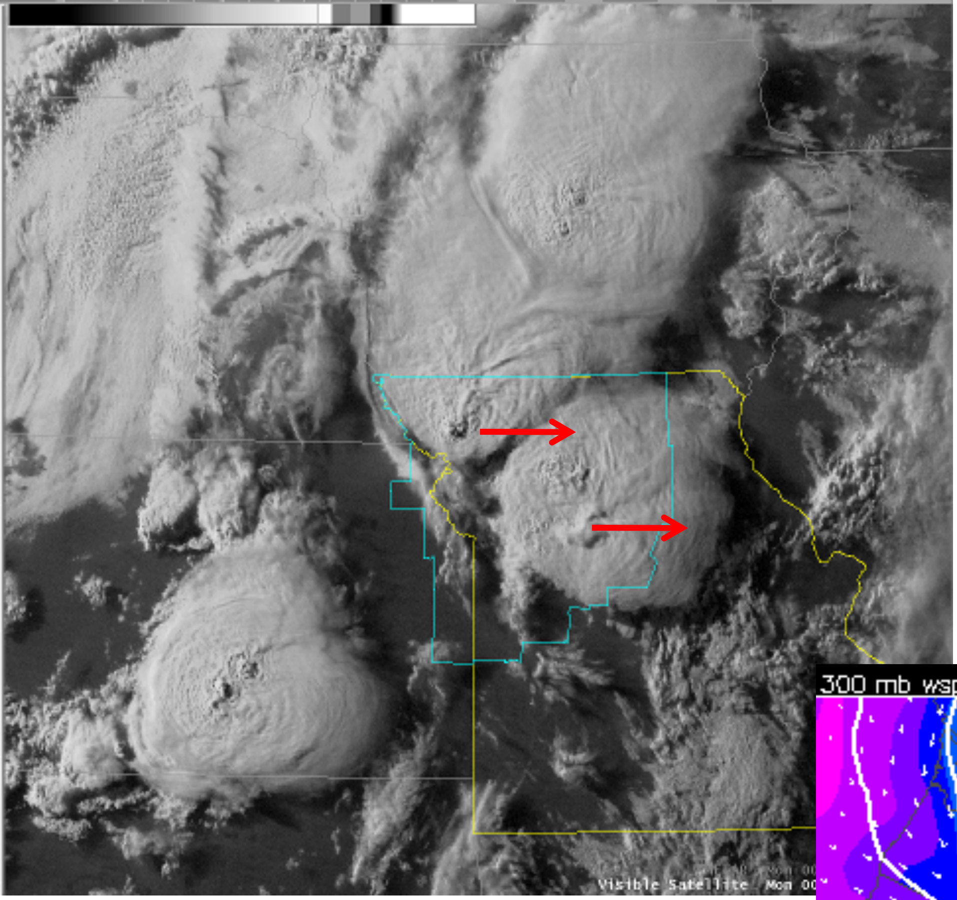
- Variable, depends upon shear and moisture availability
- Generally small cells move with the wind, or slower than the wind and to the left
- Large cells move to the right and significantly slower

Cell Motion, Storm Motion and Propagation

- Large, strong cells often move
  - slower than the mean wind
  - to the right of it.
- They tend to form on the right, or right rear flank of the storm
- Causing the storm to move even more to the right of the wind
- They can form on the upwind side causing a stationary train of cells

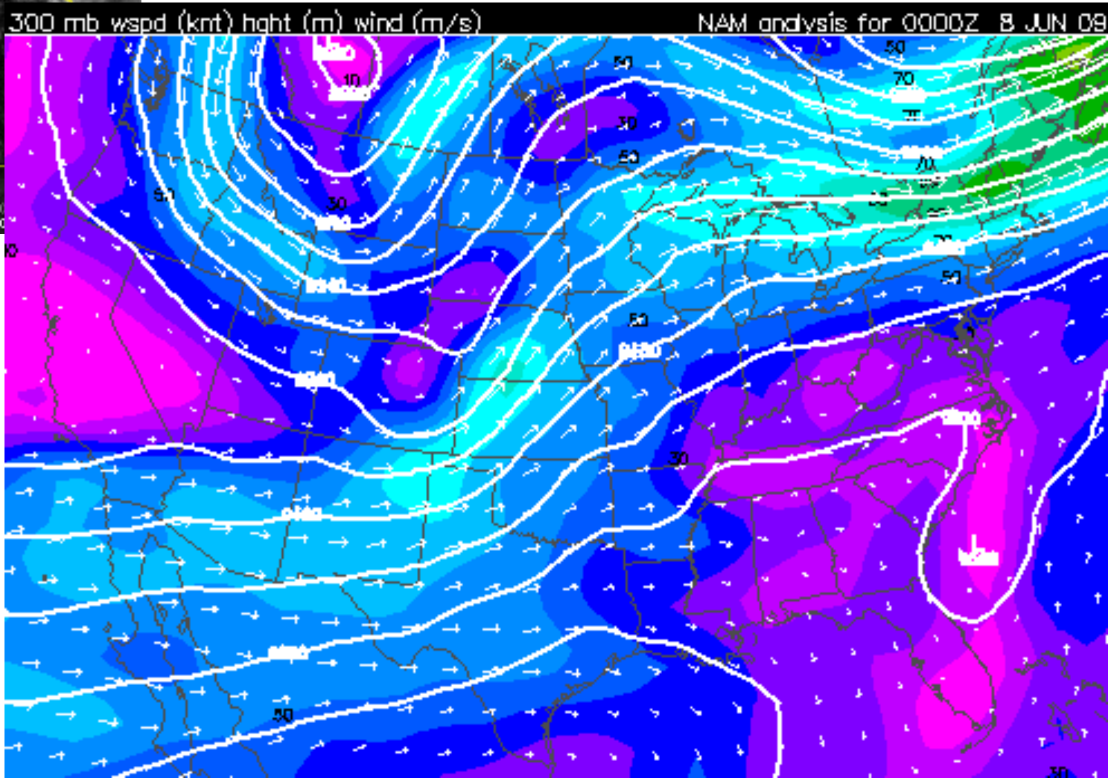


C = Cumulus
M = Mature
D = Dissipating

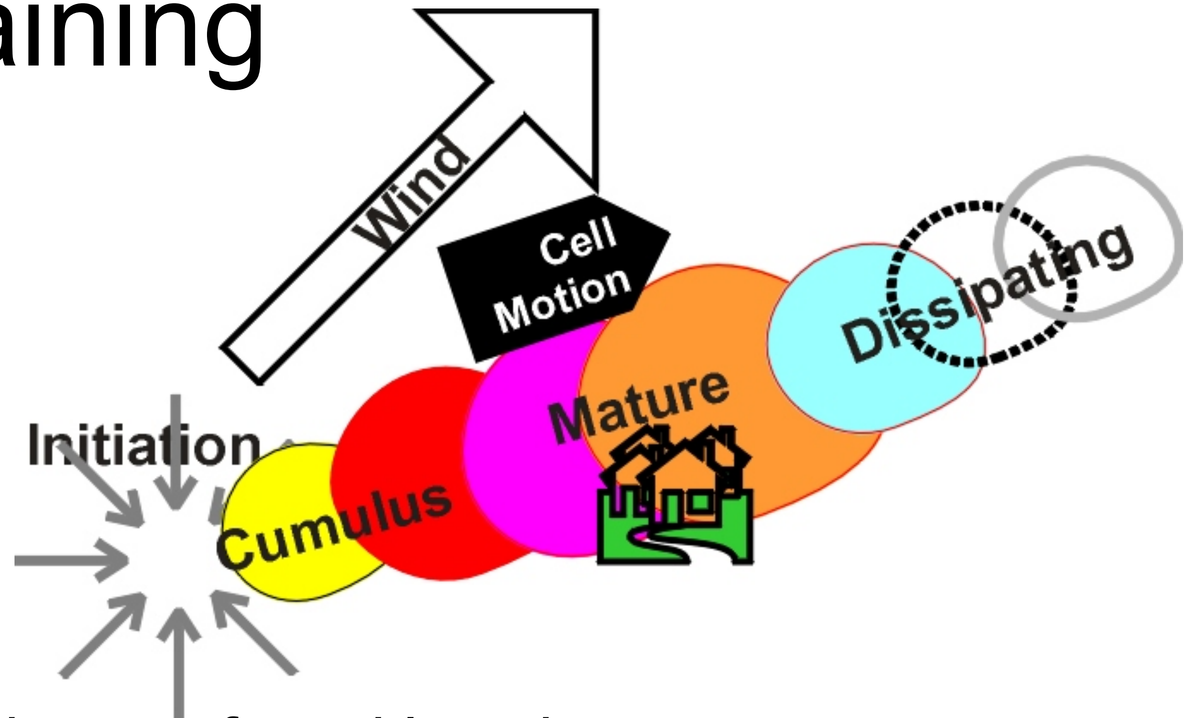


Storm outflow follows mean wind from SW – NE

Storm motion is to right of mean wind, nearly due east in this case



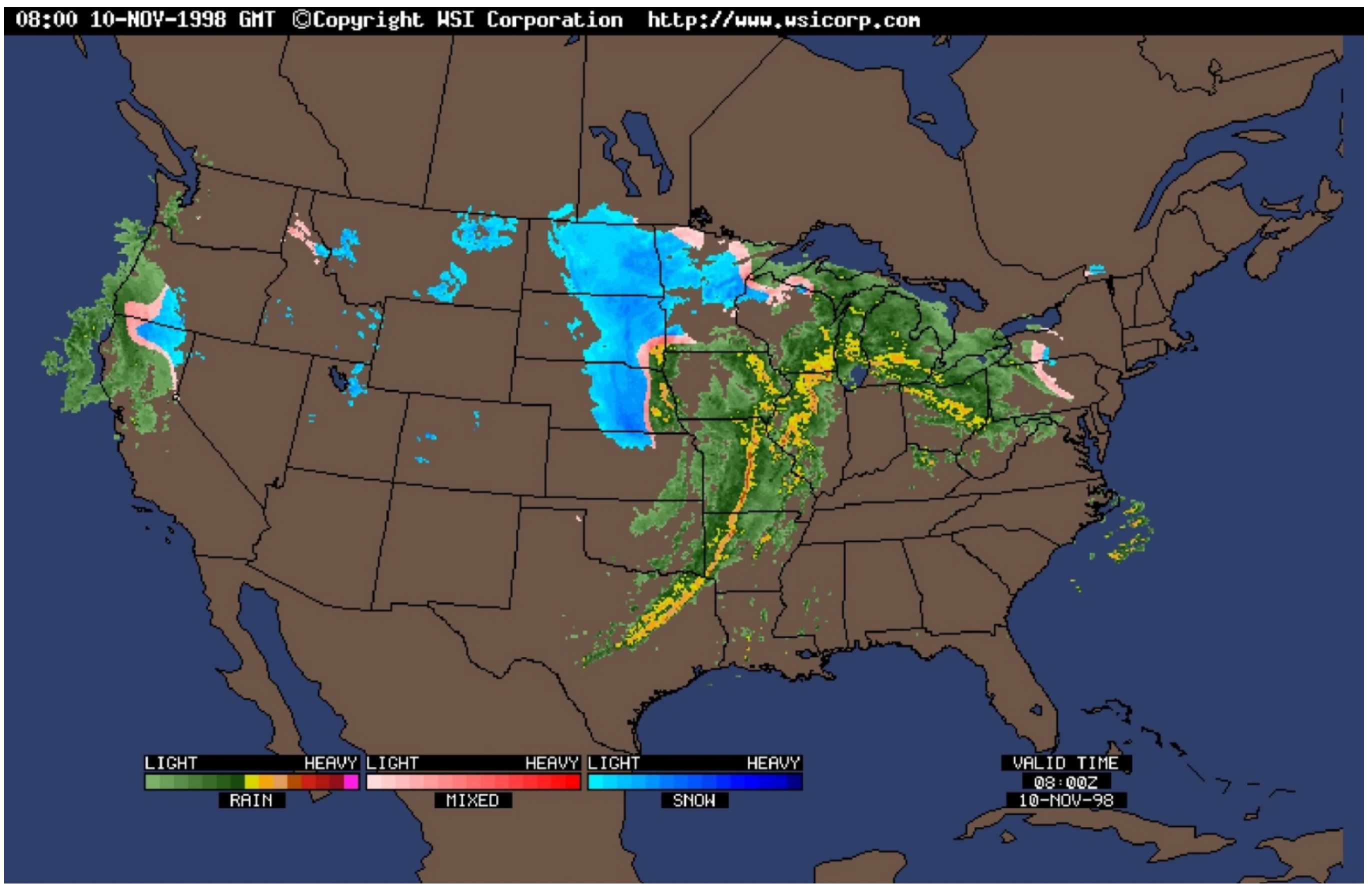
Cell Training



- Cells initiate in a preferred location
- Each follows nearly the same path downwind
- Over a locale that is likely to get flooded
- Storm as a whole appears to remain stationary, although individual cells initiate, mature and die as they move through it

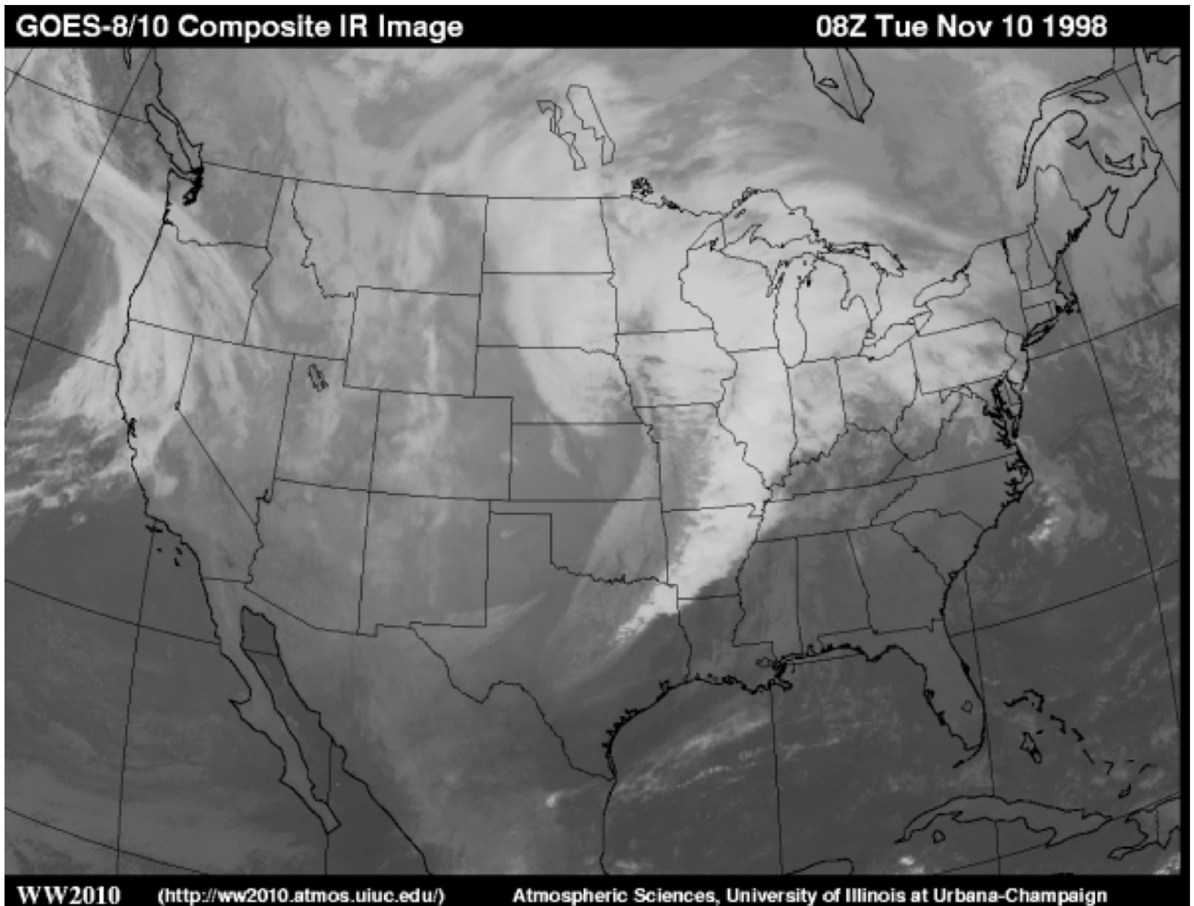
Frontal Squall Lines

- Form in the warm moist air ahead of surface cold fronts and dry lines, or just ahead of an upper-level front.
- Form the tail of the comma-cloud.
- A line of high reflectivity (convection) with lighter more stratiform rain both to the rear (west) and sometimes ahead (east) of the convection.



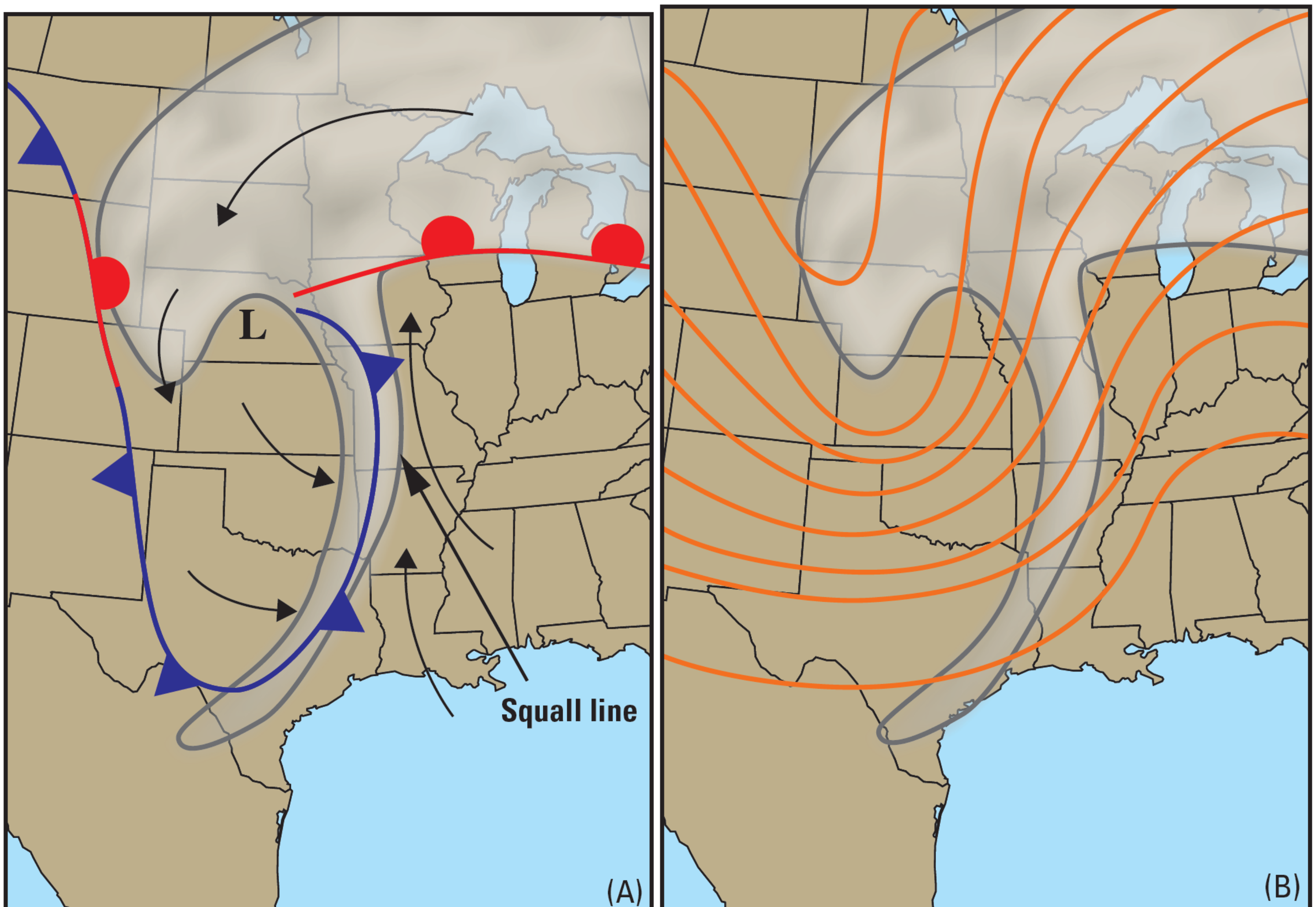
Frontal Squall Lines on an IR image

- A long line of deep (white, cold) clouds.
- Long lifetimes: many hours to days (new thunderstorms can be continuously triggered along the line).

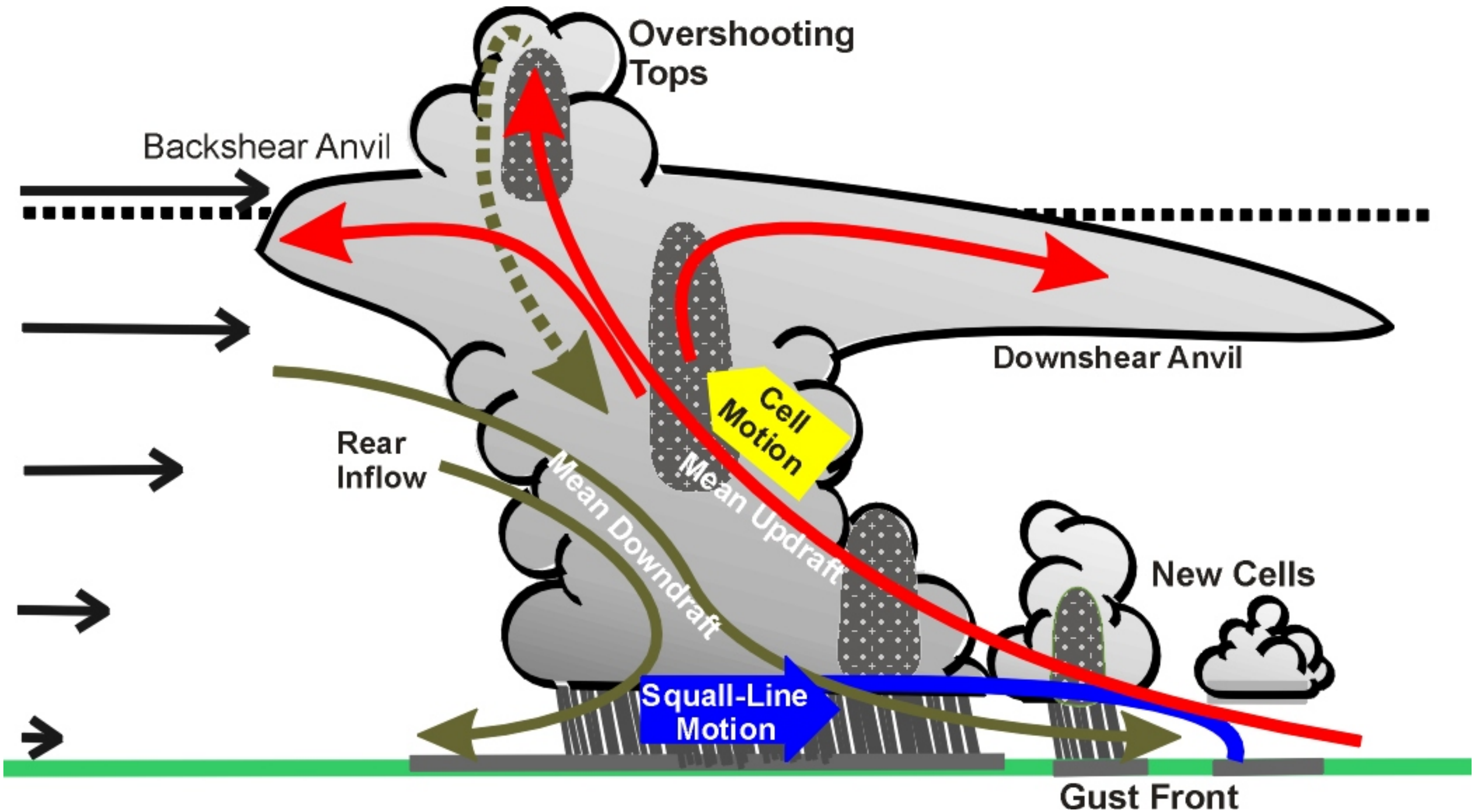


Surface & Upper Level Structure

- A low-pressure center is under the divergent region of the upper-level trough.
- At surface, SE or S winds to the east of the squall line;
- Middle to upper level winds: S or SW, much stronger than surface winds.

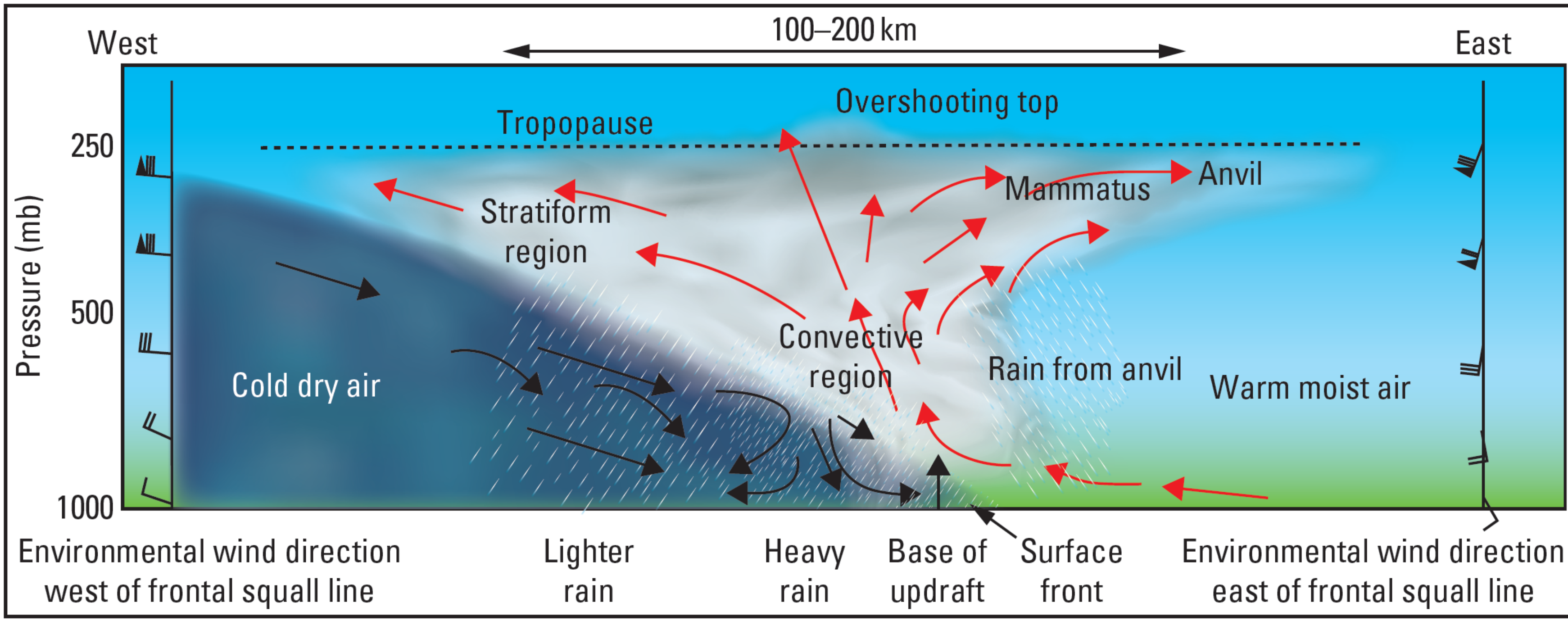


Mid-Latitude Squall Line Anatomy



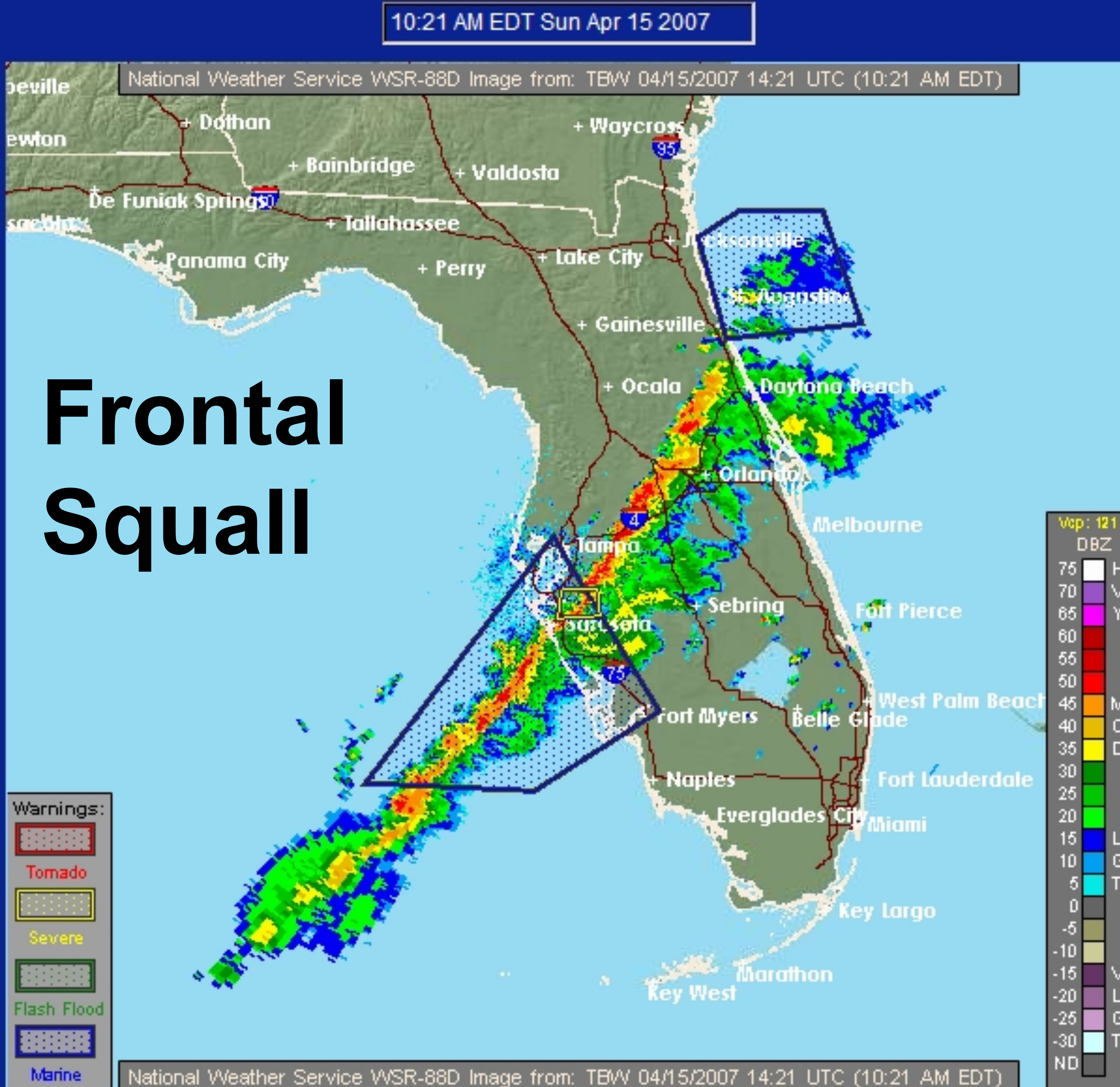
Backshear anvil can be much more extensive

Structure of a Middle Latitude Squall Line



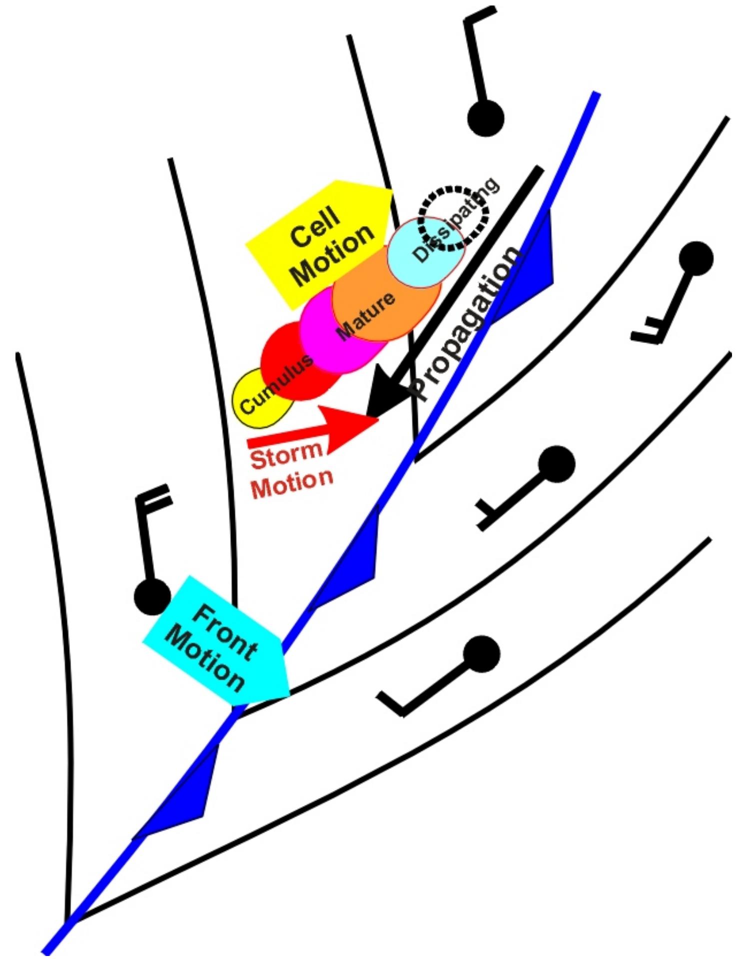
Shear profile: slightly veering wind east of the squall line (turn clockwise with height)
Directional shear = relatively weak
Speed shear = very strong

Frontal Squall



Motion of Synoptically Forced Frontal Squall Lines

- Form in air above the frontal surface
- New cells form on the S or SW flank and move N or NE
- Propagation and cell motion nearly cancel
- Storm moves slowly up the front following the frontal boundary



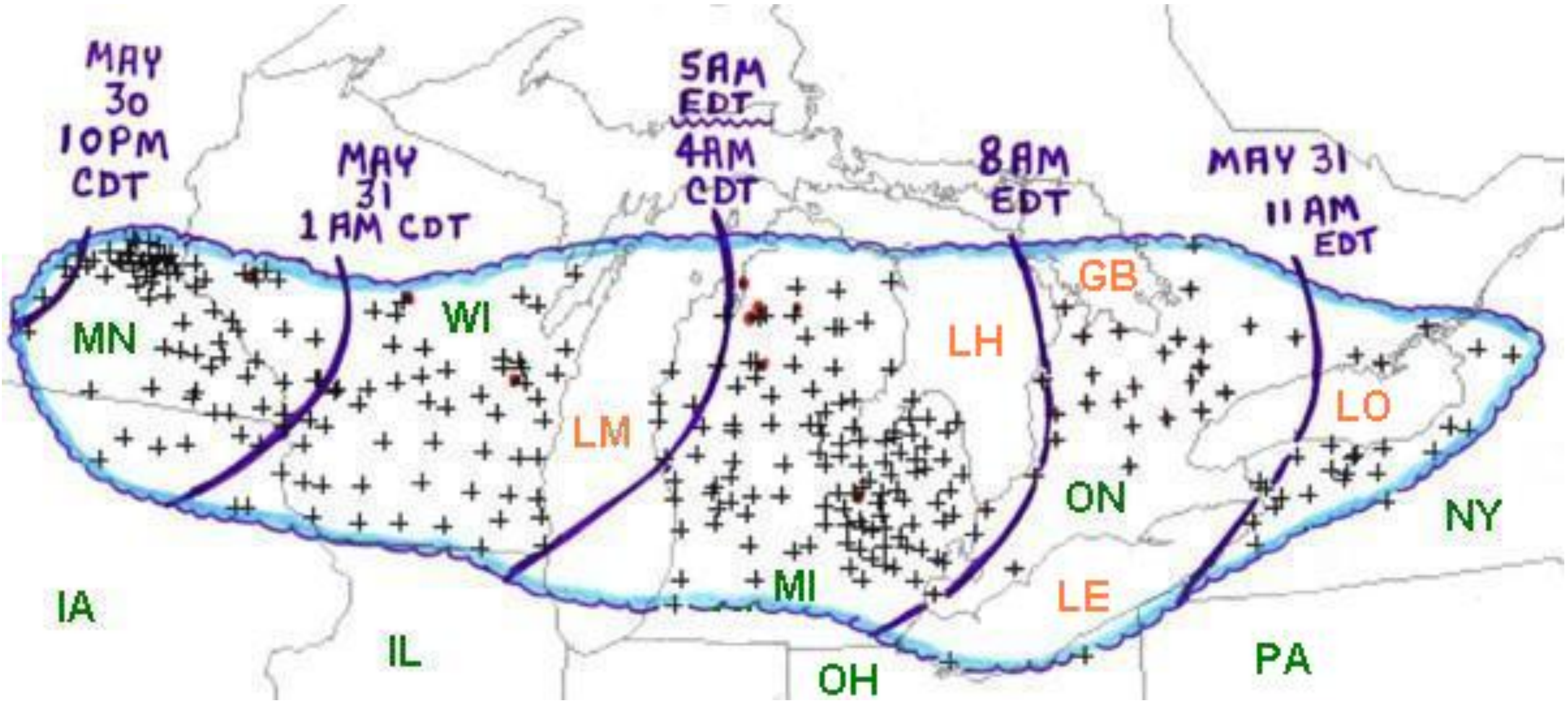
Hazards associate with frontal squall lines

- Weak tornadoes
- Strong straight-line winds
- Flash flooding led by **cell training**:
  - When the front is moving slowly or is nearly stationary, the individual cells composing the line move parallel to the front rather than advancing eastward
  - All cells move along the same track like the boxcars of a train.

Derecho

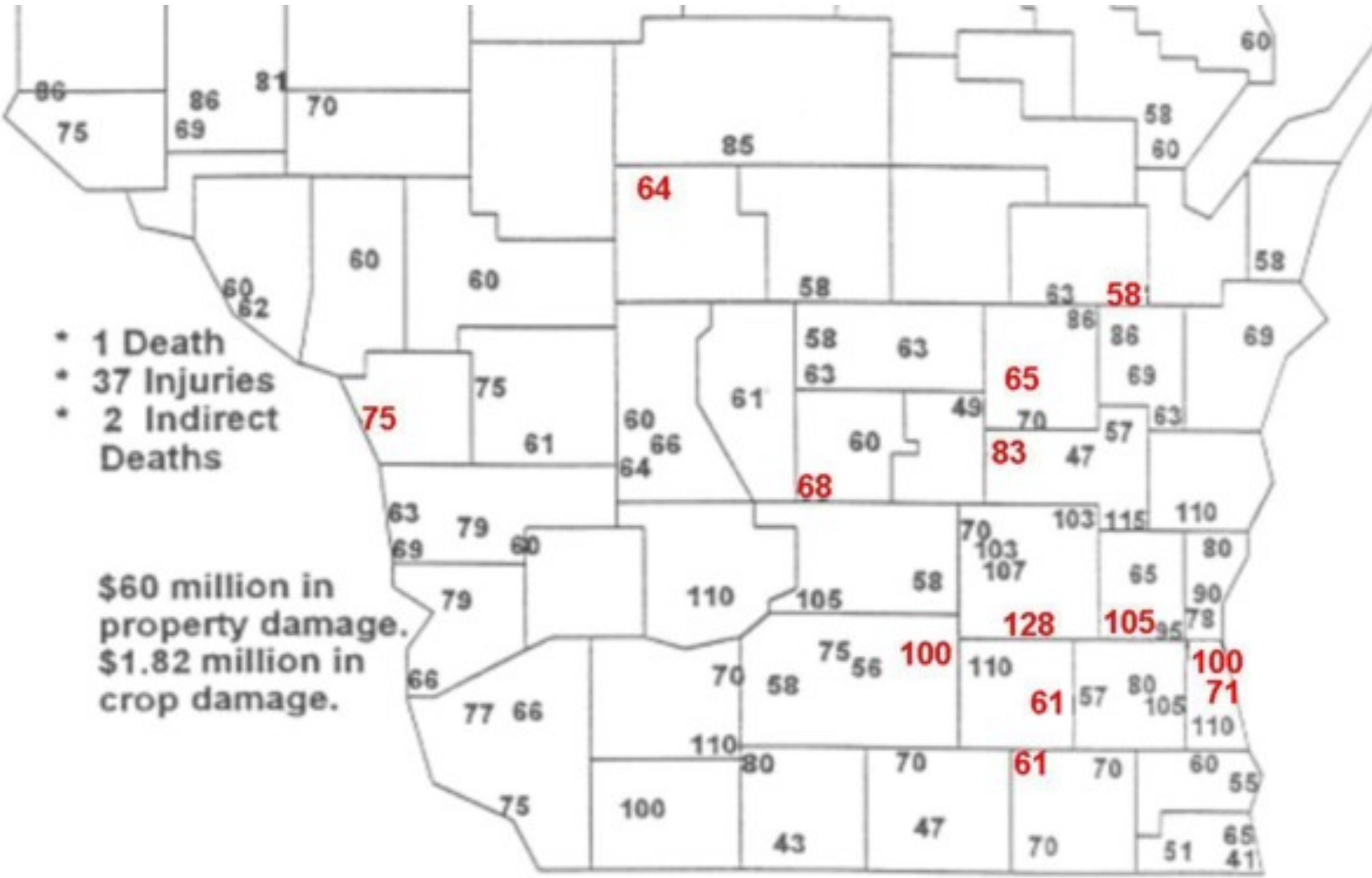
- Long lived squall line with entire line meeting severe wind criteria (58 mph winds for over 6 hours)
- Very similar structure as a normal squall line, except more intense and longer lived
- Tends to follow stationary fronts separating a warm, moist airmass and a cool, dry airmass. It is theorized that the vertical motion of the front assists in the vertical structure of the squall line.
- Known to produce widespread Cat 1-2+ Hurricane force winds

May 30-31, 1998 Derecho Over the Great Lake Region



LM: Lake Michigan
LH: Lake Huron
LE: Lake Erie
LO: Lake Ontario

Maximum Wind Gust



- 1 Death
- 37 Injuries
- 2 Indirect Deaths

$60 million in property damage. $1.82 million in crop damage.

Radar loop of the May 31, 1998 derecho as it travels across lower Michigan.

http://en.wikipedia.org/wiki/File:May_1998_Derecho_Radar_Loop.gif

Summary

- Shear controls convective organization
  - Little or no precipitation loading in sloping updrafts
  - Outflow boundaries initiate new cells
- Cell motion plus propagation due to new cell formation contribute to storm motion
  - Training, where new cells from upwind to keep the storm stationary causes heavy rainfall
  - Motion of frontal convection
- Learn structures and evolution of frontal squall lines