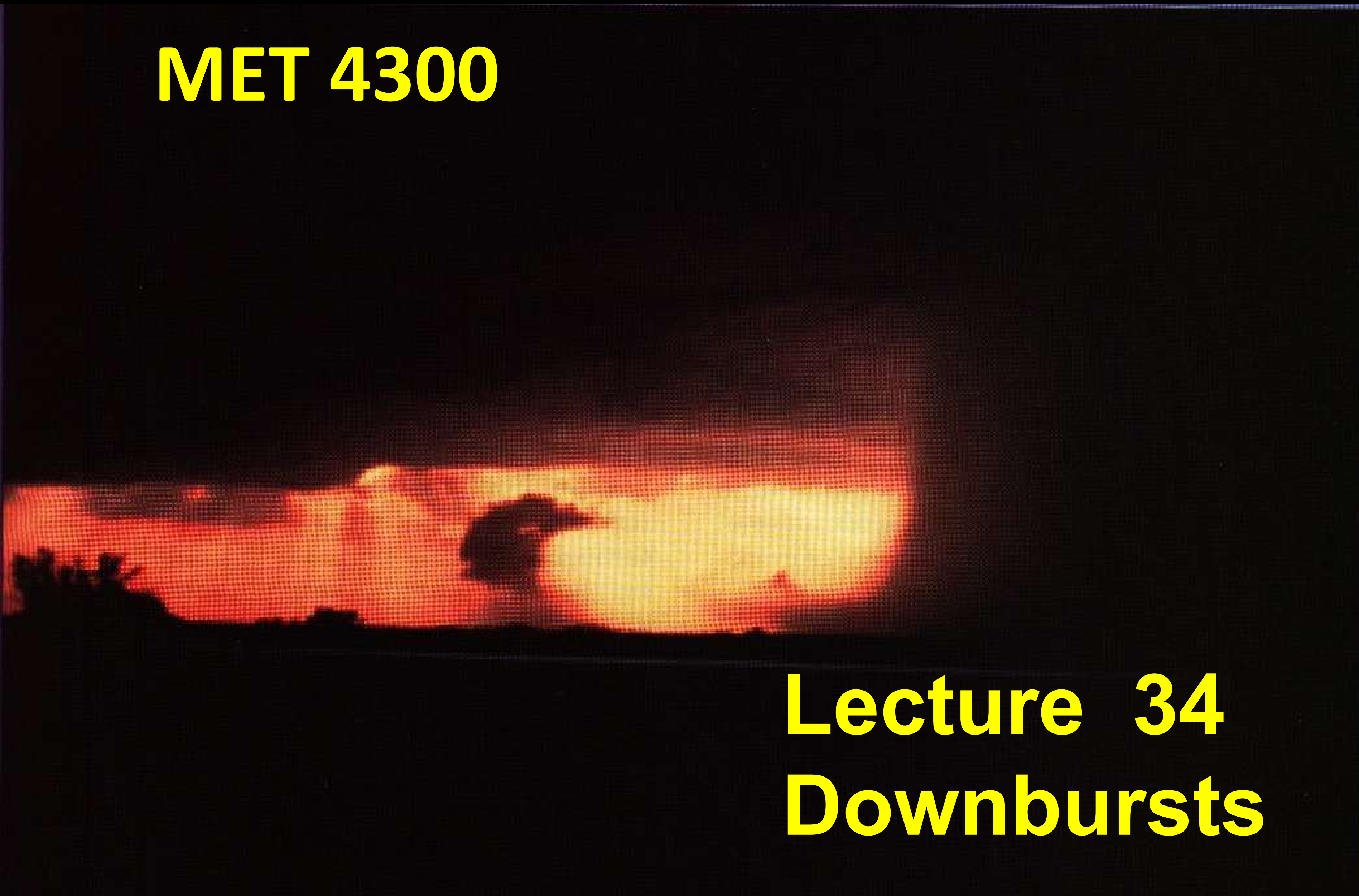
MET 4300

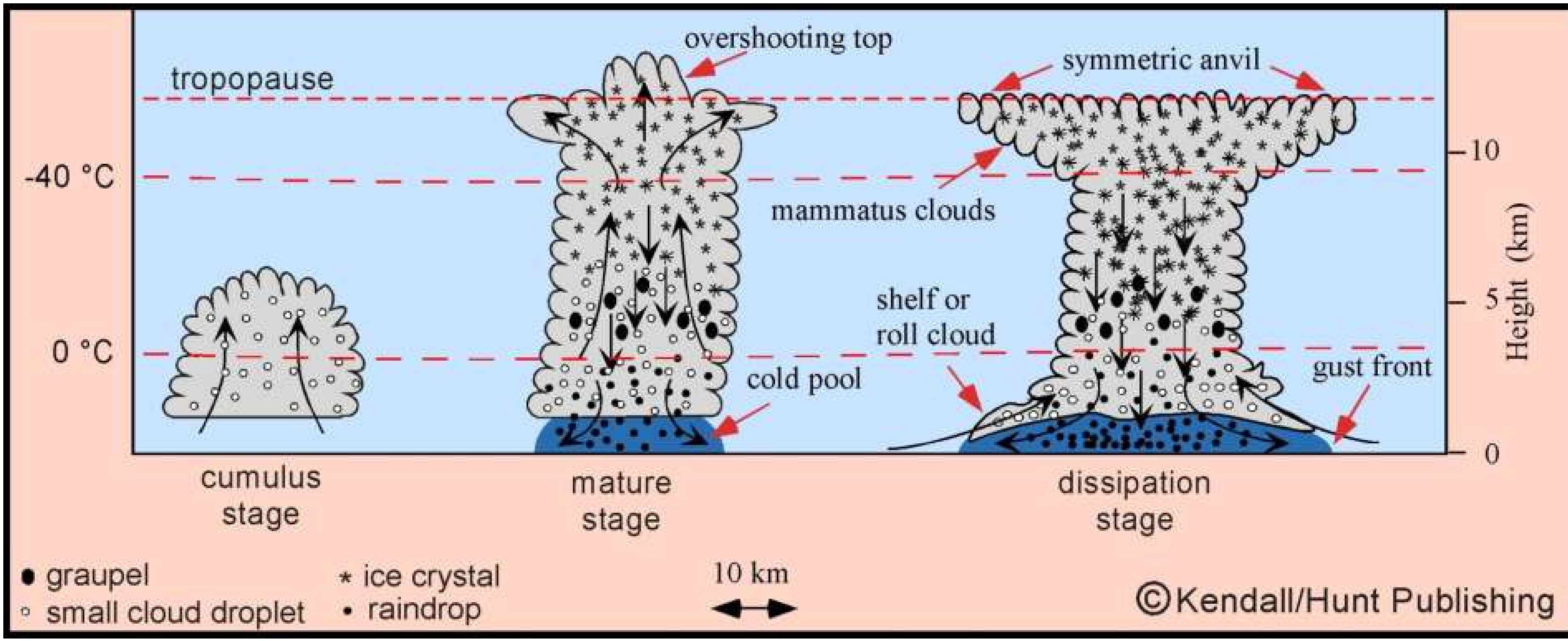


Lecture 34
Downbursts

Downbursts

- A strong downdraft that originates within the lower part of a cumulus cloud or thunderstorms and spreads out at the surface
- Downbursts do not require strong thunderstorms to develop
- Driven by hydrometeor loading and evaporation
- Downbursts < 4 km across are called "Microbursts"
- Winds can exceed 40 m/s (damage similar to weak tornado EF0 & EF1)
- Hazard to low-flying (takeoff & landing) aircraft

A cumulus cloud can evolve from the updraft stage to a downburst within minutes

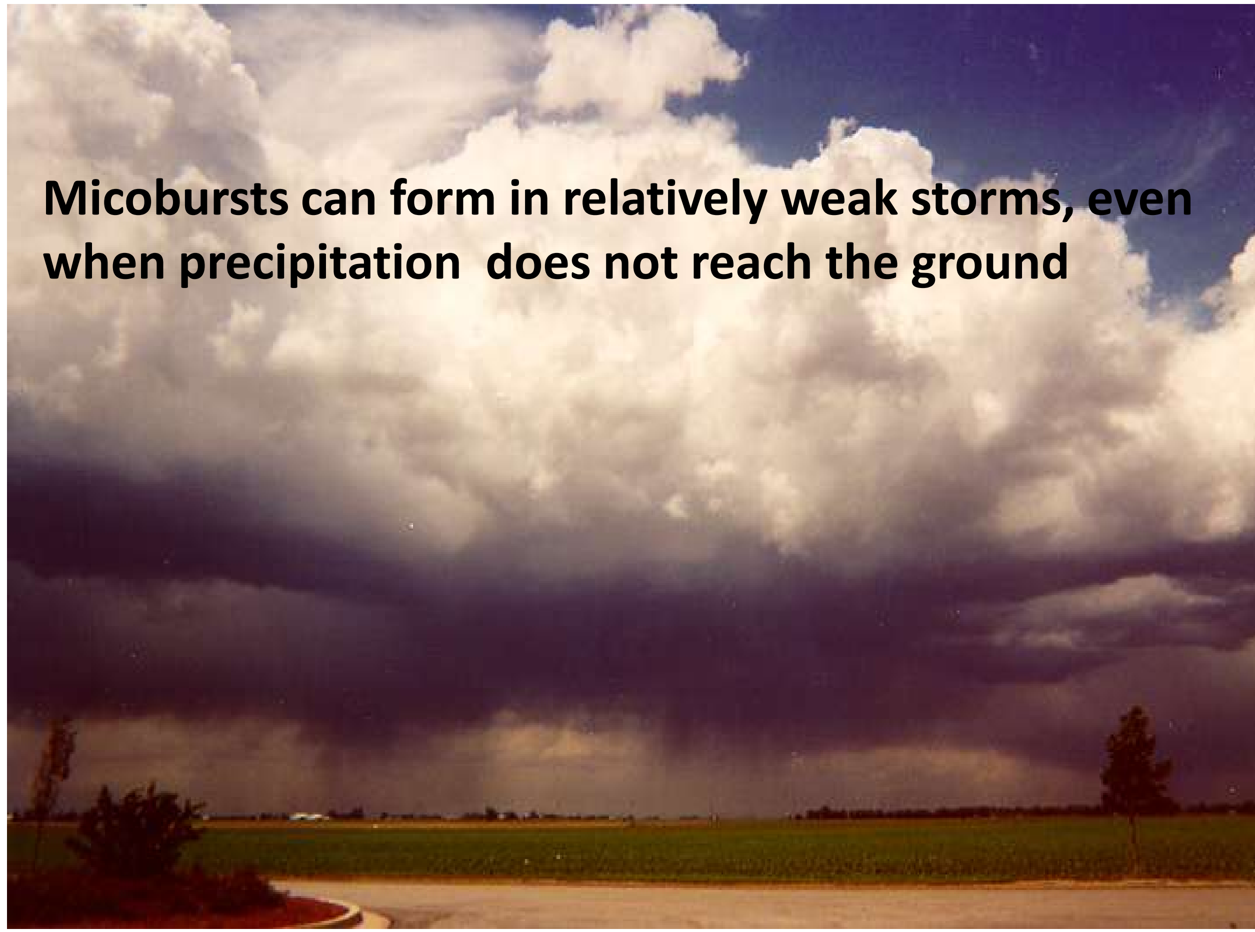


Distinctions between downbursts and typical thunderstorm downdrafts

- 1) Downbursts are much more intense and concentrated over small horizontal areas
- 2) Downbursts generally develop or intensify in the lower portions of a cloud (cloud needn't to be deep, often develop when precipitation doesn't reach ground).
- 3) Evaporational cooling is very important for downburst intensification
- These distinctions were first recognized by Fujita in the 1970s through studies of aircraft crashes
- Microburst warning systems (using Doppler radar) were implemented during the 1990s.

Downburst Formation: Two Mechanisms

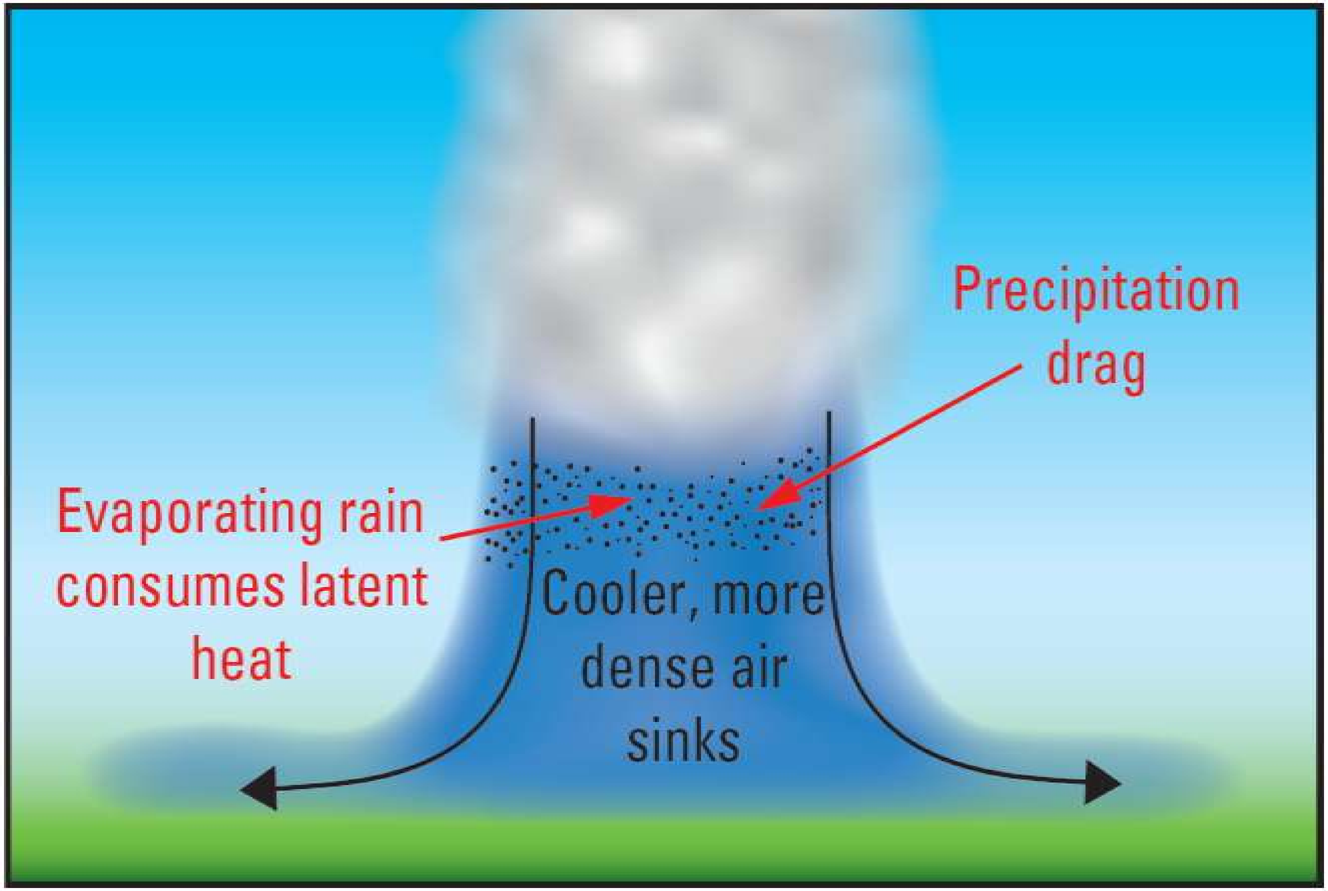
1) **Evaporation mechanism (most important):** Evaporation from rain cools the air. The rain-cooled air is colder and more dense than its environment, and begins to sink. The rate of sinking depends on the temperature difference, several degrees cooler can cause downward speeds of 35-50 kts.



"*Virga,*" liquid hydrometeors that evaporate before they strike the earth

Downburst Formation: Two Mechanisms

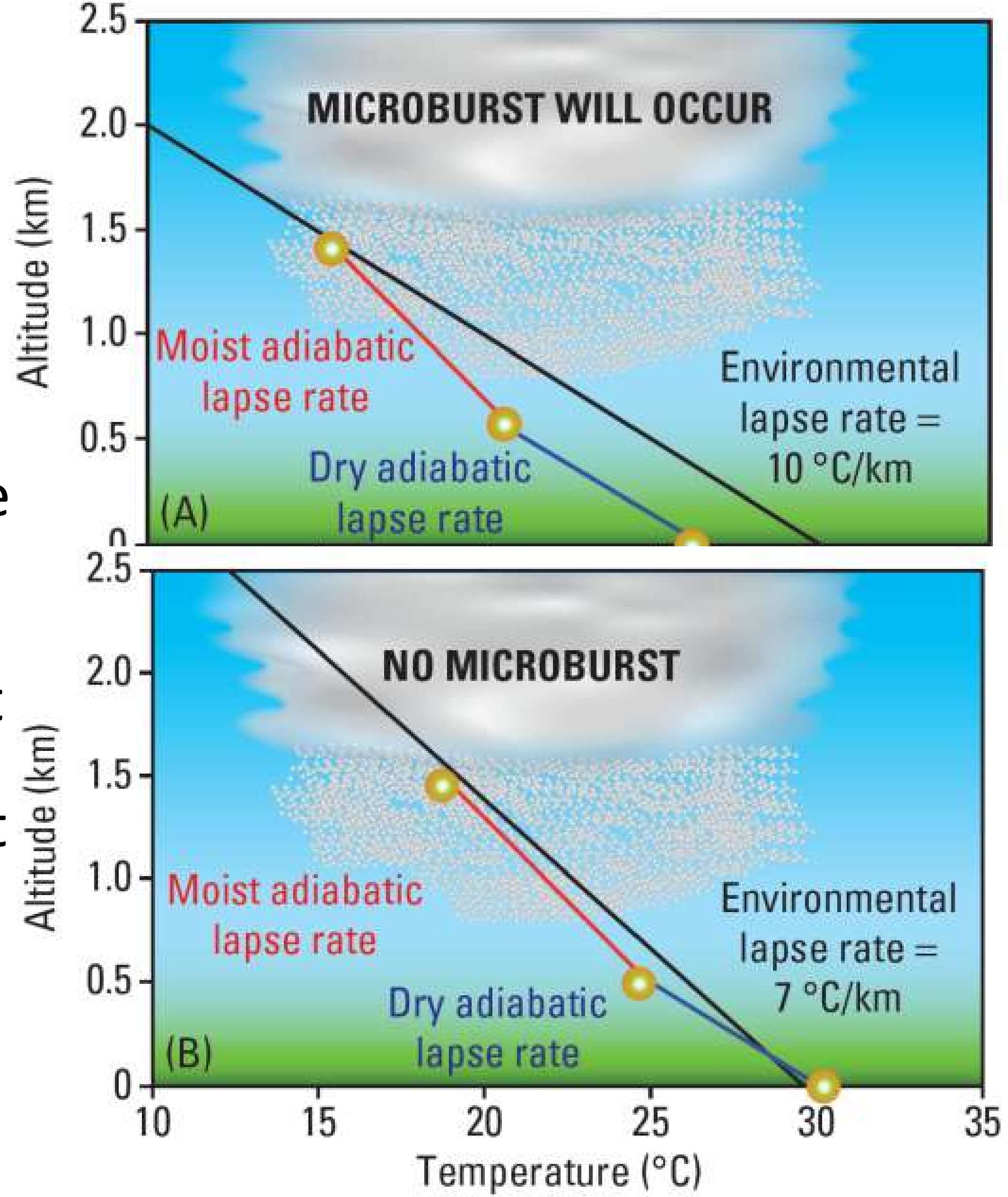
2) **Falling Precipitation drags:** The second mechanism driving air downward is the drag force of the falling precipitation.



In downburst formation, both the heaviest rain and evaporation below the cloud base are concentrated in a small area (several hundred meters to a few kilometers across), in contrast to other showers and thunderstorms. This is why downbursts have stronger winds.

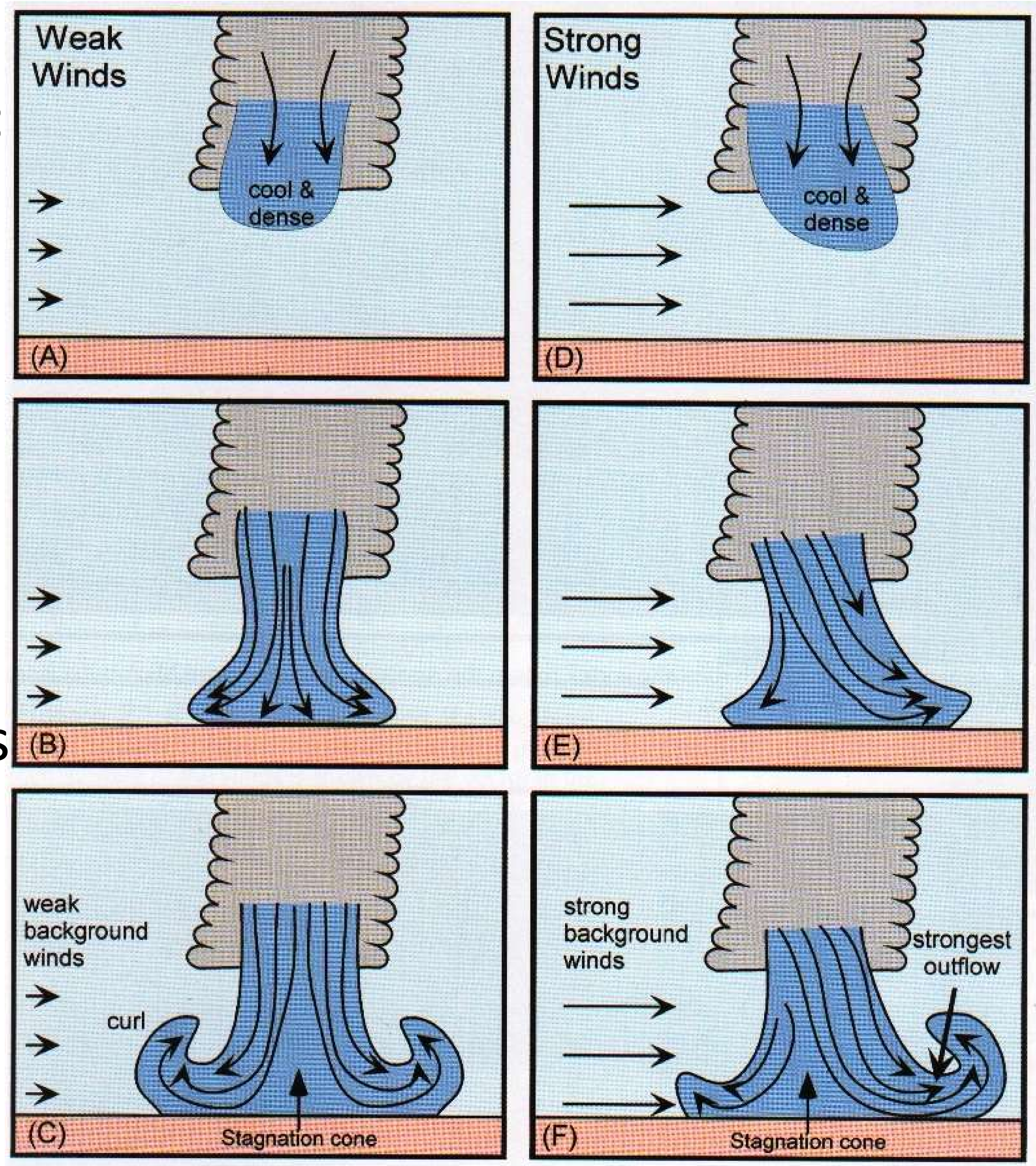
Necessary Conditions for Microbursts

- Large environmental lapse rate below could base (~10 C/km)
- Dry air below cloud base: increase evaporation
- An increase in moisture near the surface: increase negative buoyancy
- Below-freezing temperatures throughout much of the cloud: more cooling due to latent heat of melting by falling ice particles than by falling raindrops.

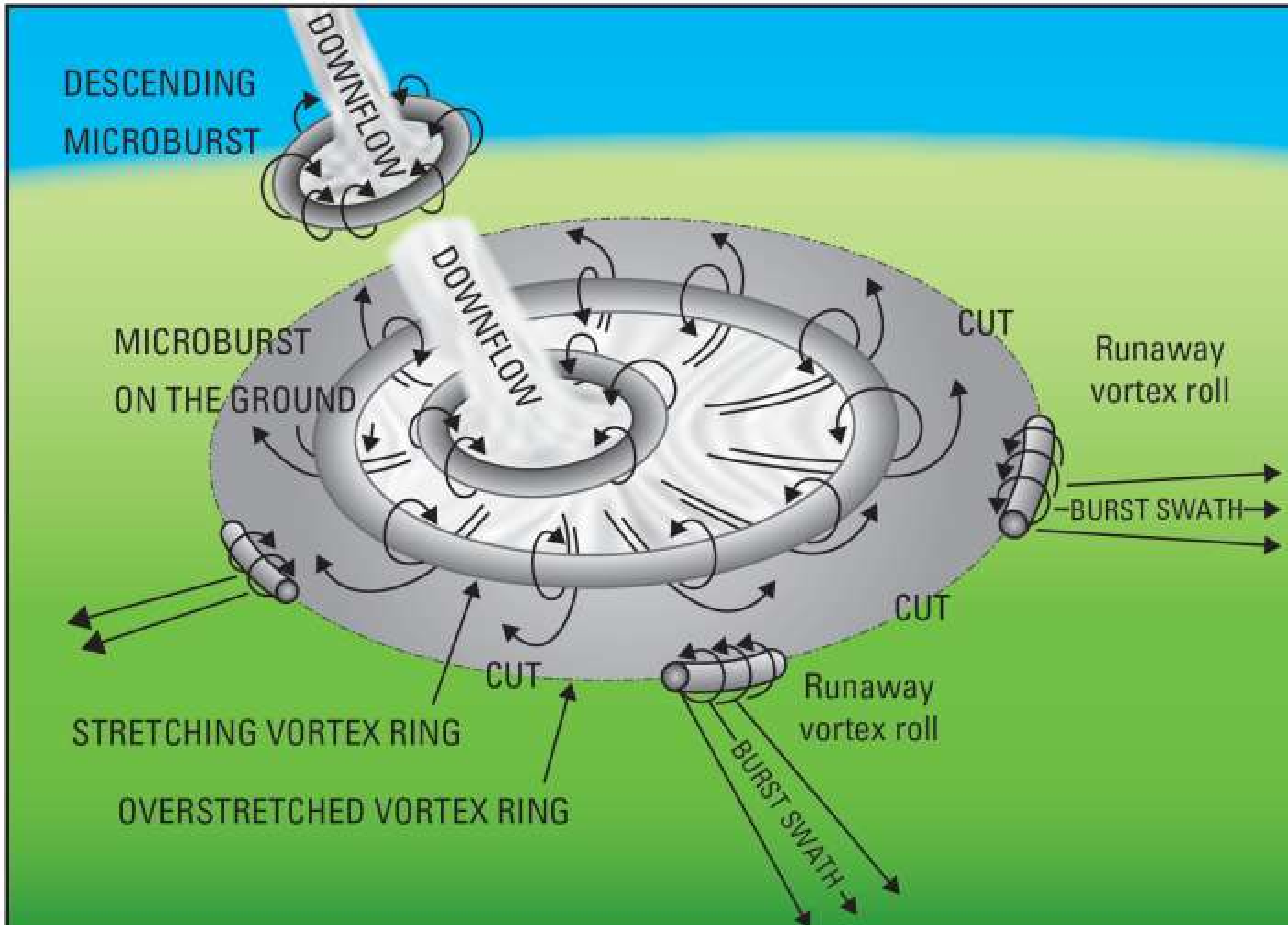


Downburst Structure: With and Without strong background Winds

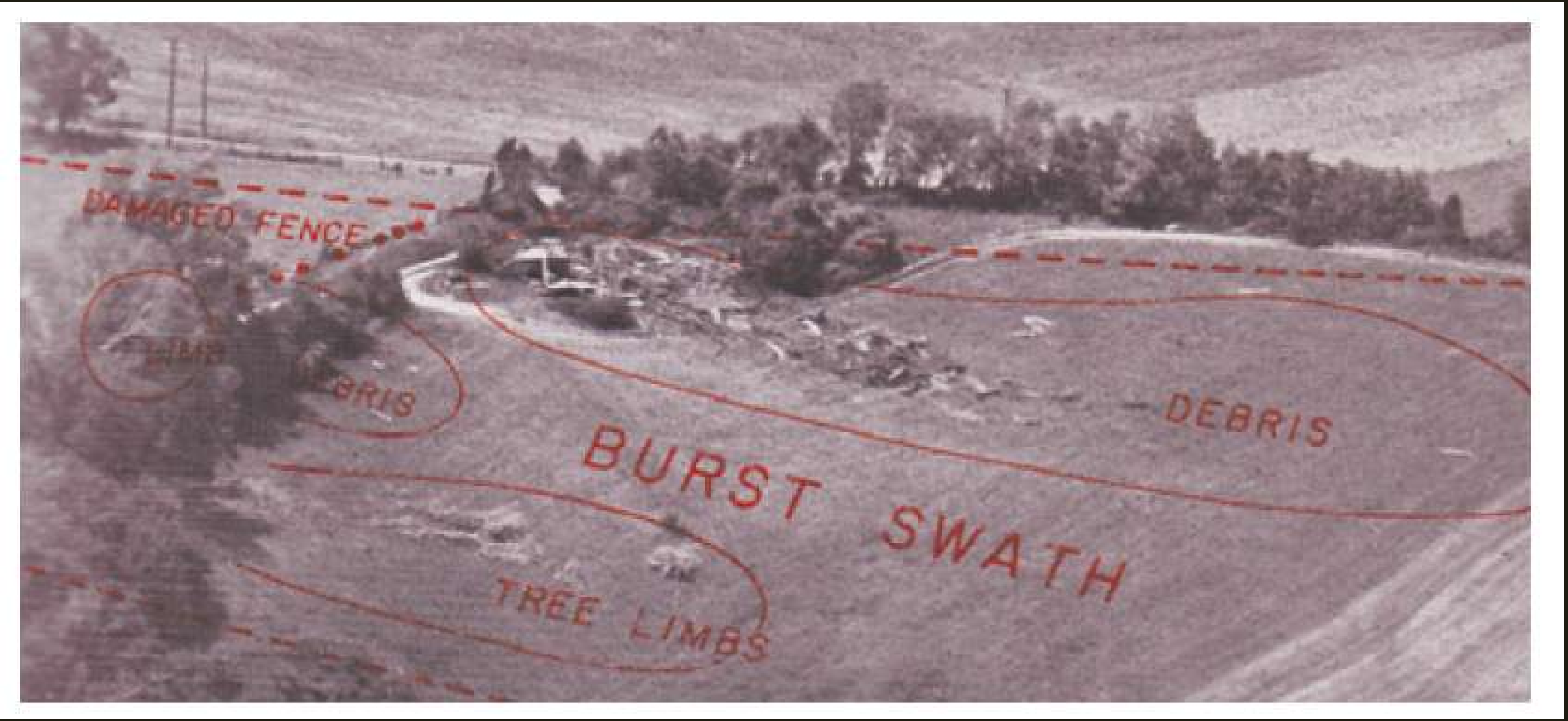
Max. wind speed at 30-50 m above the ground at the base of the ***curl.,*** appearing as a ***vortex ring.***



Vortex ring at various stages of evolution of a microburst. **The vortex ring migrates outward from the center. Portions of the ring may break away, creating runaway vortex that produce localized wind bursts and damage swaths**



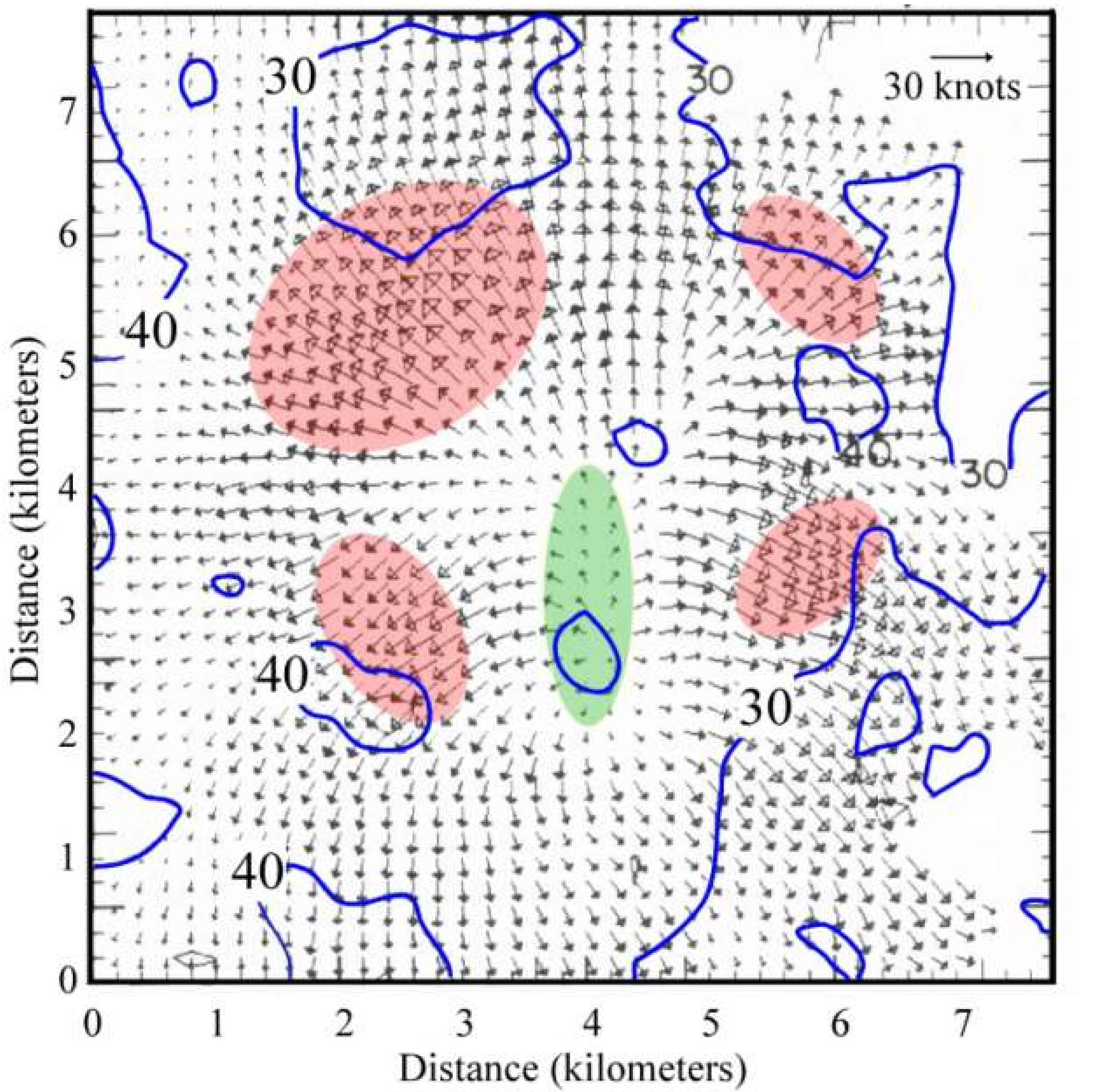
Damage pattern associated with runaway vortex rolls in the Andrews AFB microburst on Aug. 1, 1983



A downburst near Denver CO (the shape of precipitation shows the downburst)

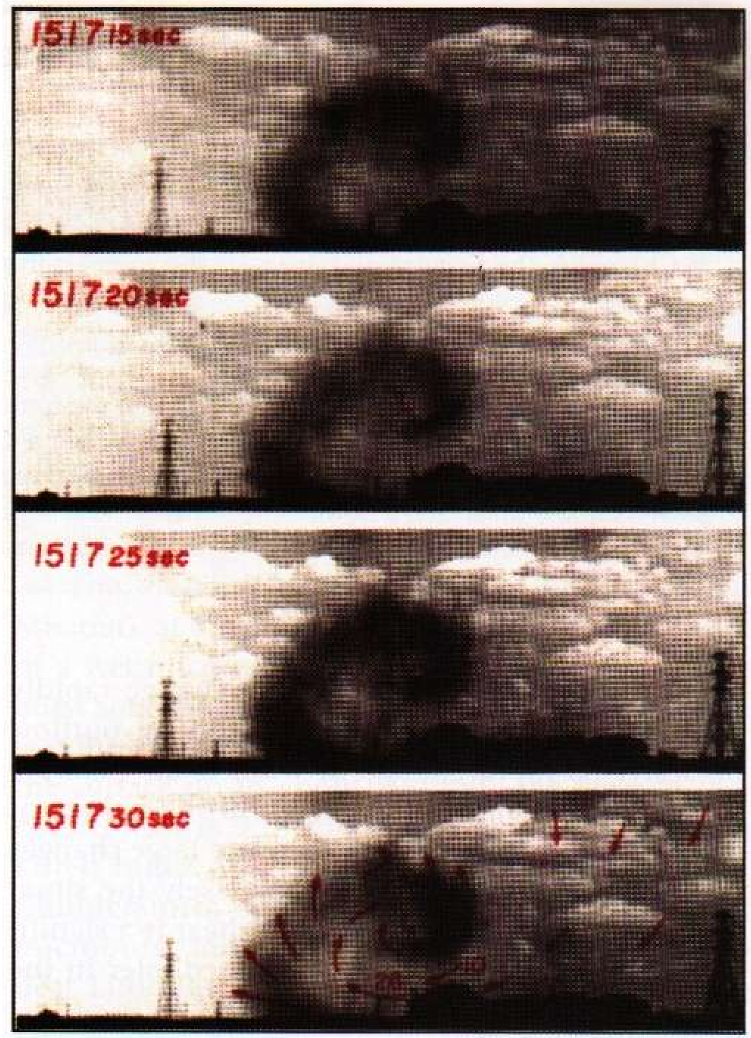
Low-level winds from a downbusrt deduced from multiple Doppler radar.

Curl regions: Larger arrows
Contour: rfelctivity
Green: microburst center
Pink: burst swath



Structure of the Swaths and Vortex Ring

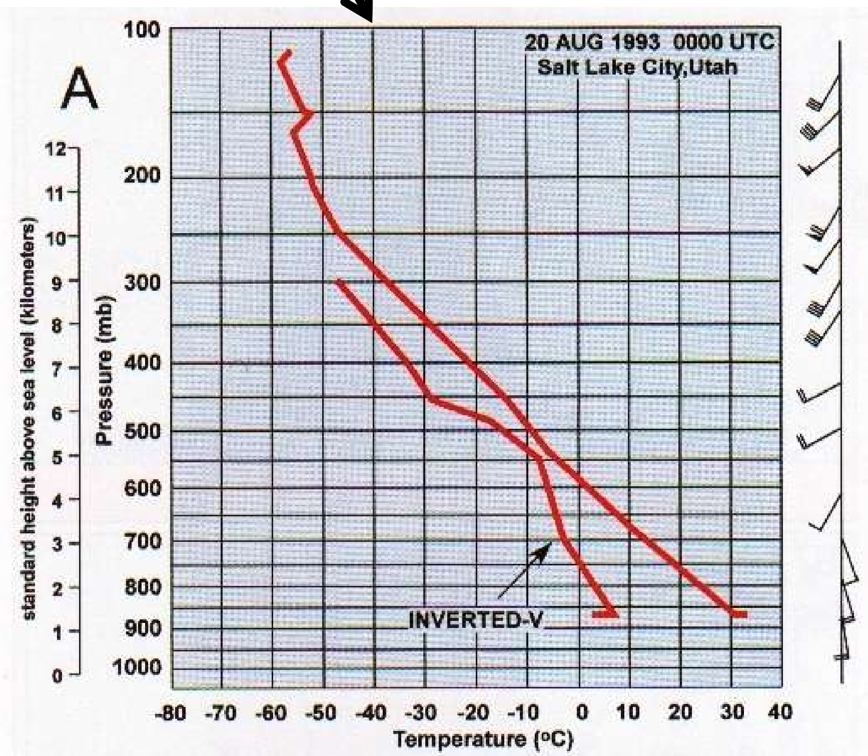
- Curling motion of the dust cloud behind the leading edge of a downburst advancing from right to left over a 15-second period.

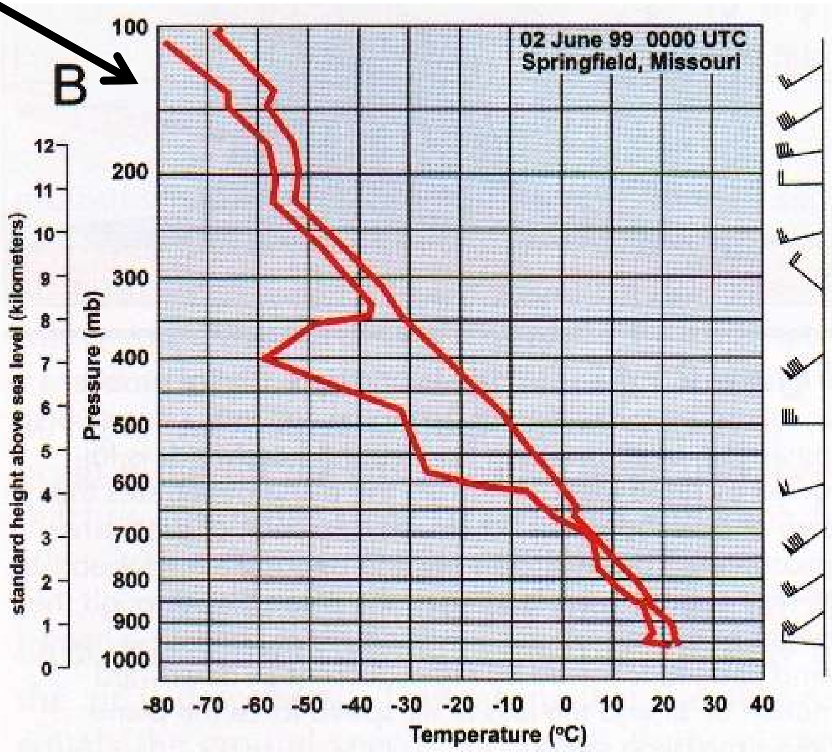


Types of Microbursts: Dry and Wet

- Wet microbursts: accompanied by measurable rain, more easily visible (rainshafts as curtain reaching the ground). Common in the South, Midwest, and East.
- Dry microbursts: have no measurable precipitation, virga can often be seen, and also blowing dust. Common in wetern US and the Great Plains.

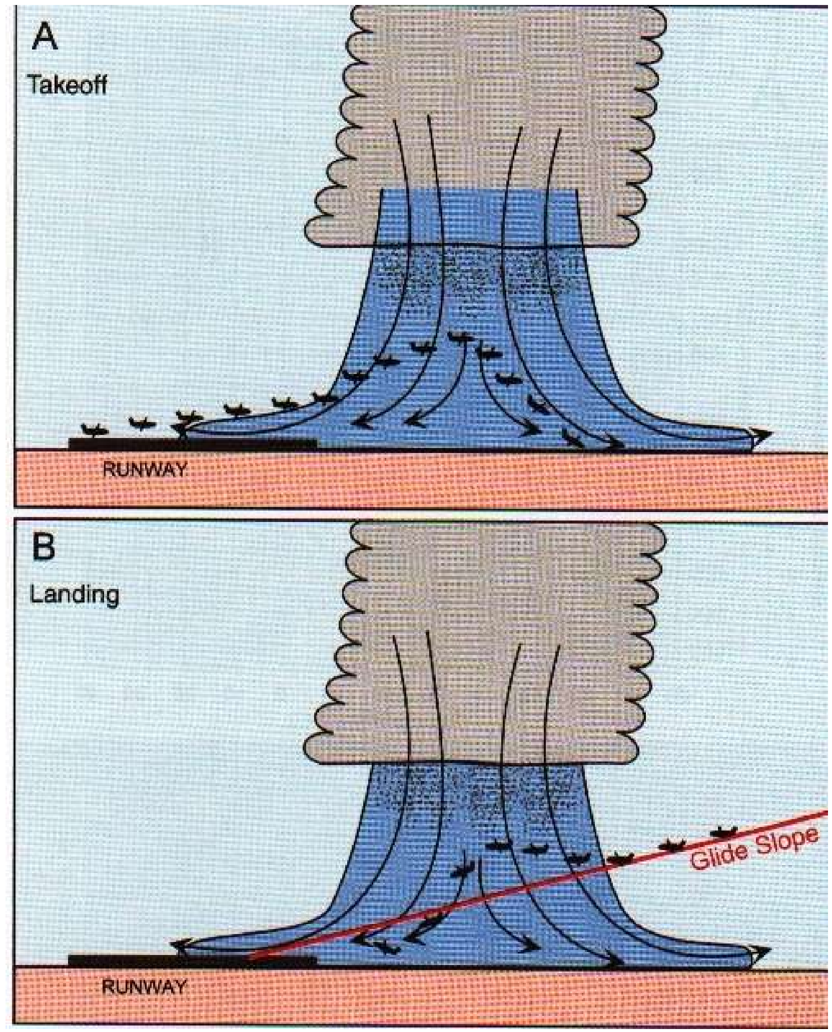
Types of Microbursts: Dry and Wet Microburst Soundings



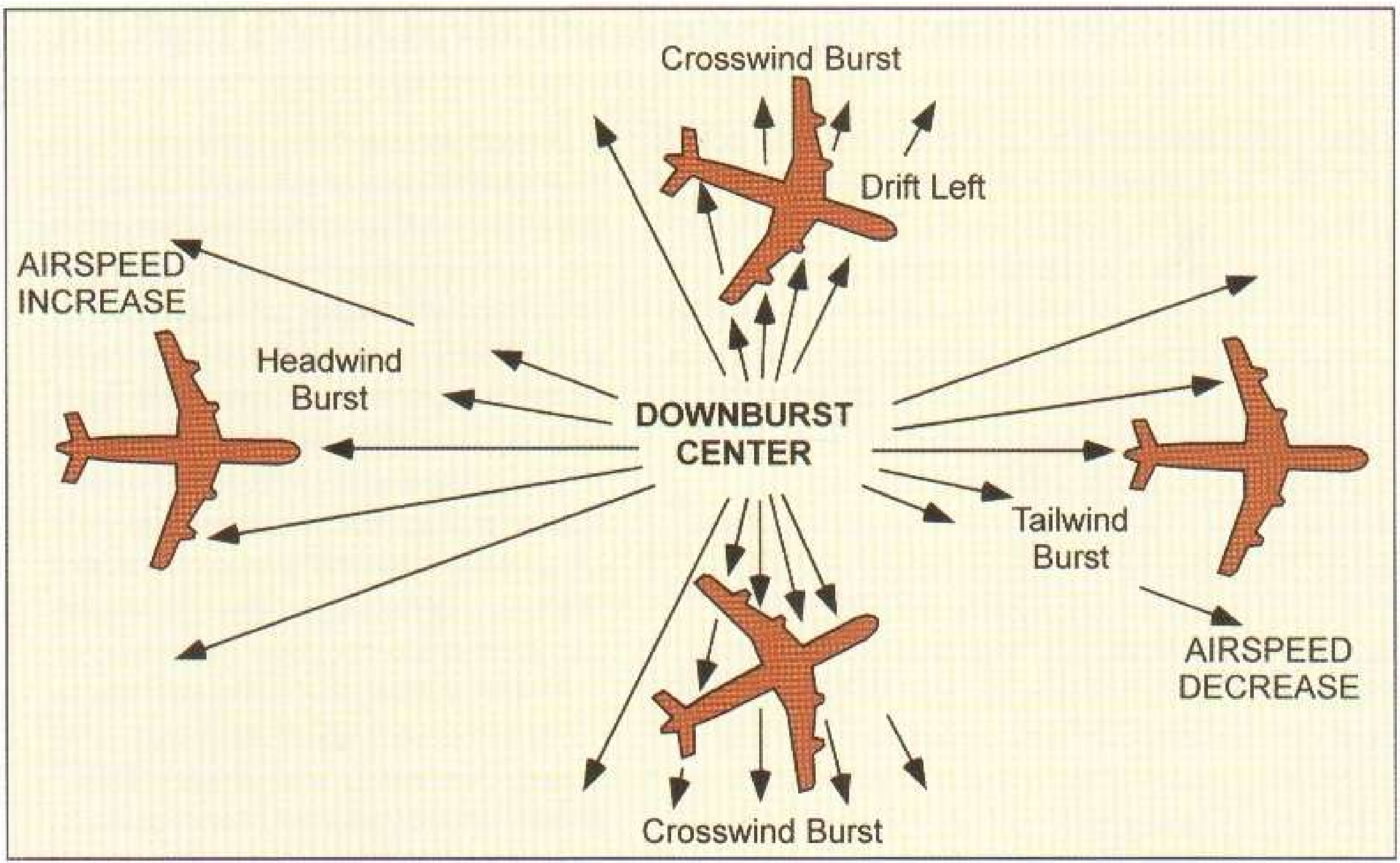


Aircraft Encounter Downbursts

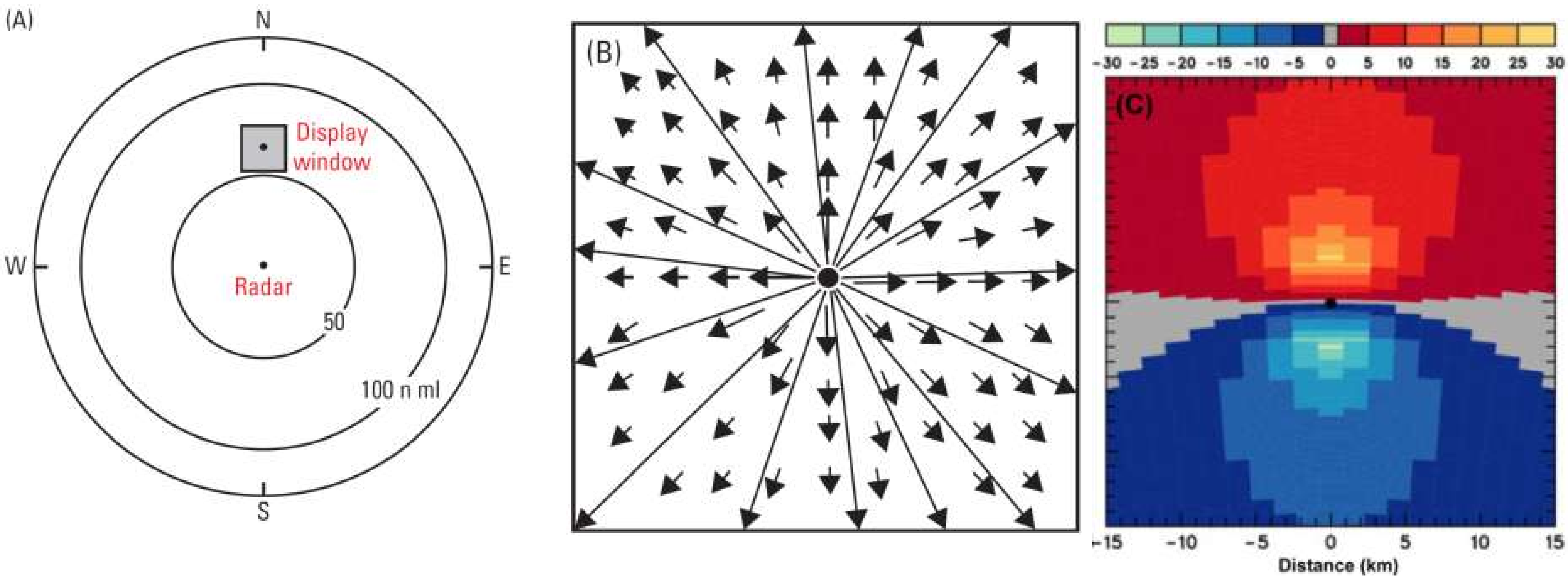
- **Airspeed** = ground speed + headwind (-tailwind)
- An aircraft need to maintain a certain airspeed (**stall speed**) to maintain in the air. Otherwise, it will stall, lose lift and go out of control.
- Headwinds approaching the burst
- That switch abruptly to tailwinds on passing the stagnation point
- Sudden loss of airspeed
- Can be avoided by allowing airspeed to build up and even a drift above the glidepath



If a plane passes through the right or left side of a microburst, outflow winds cause lateral drift from the intended path.



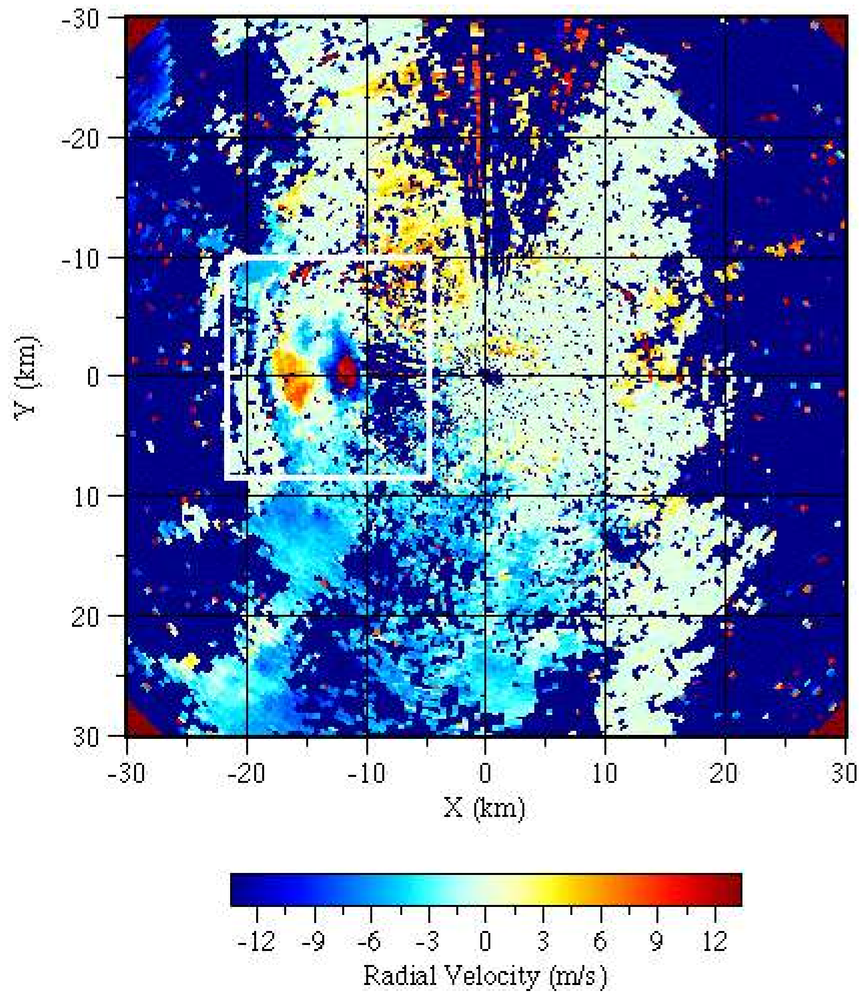
Detect Microbursts by Doppler Radar



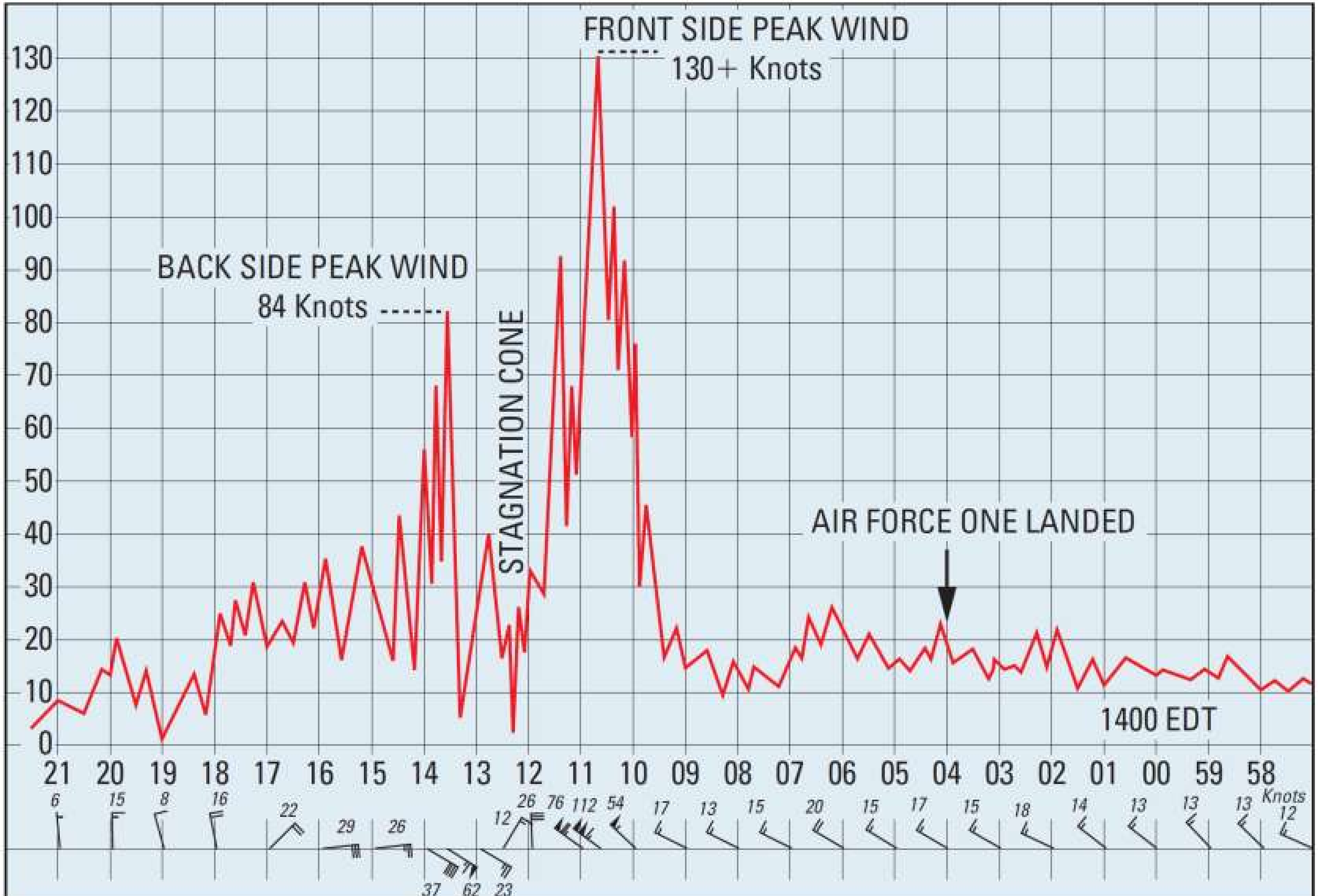
Toward-way couplet oriented parallel to the wind

Airport Terminal Doppler Weather Radar (TDWR) system

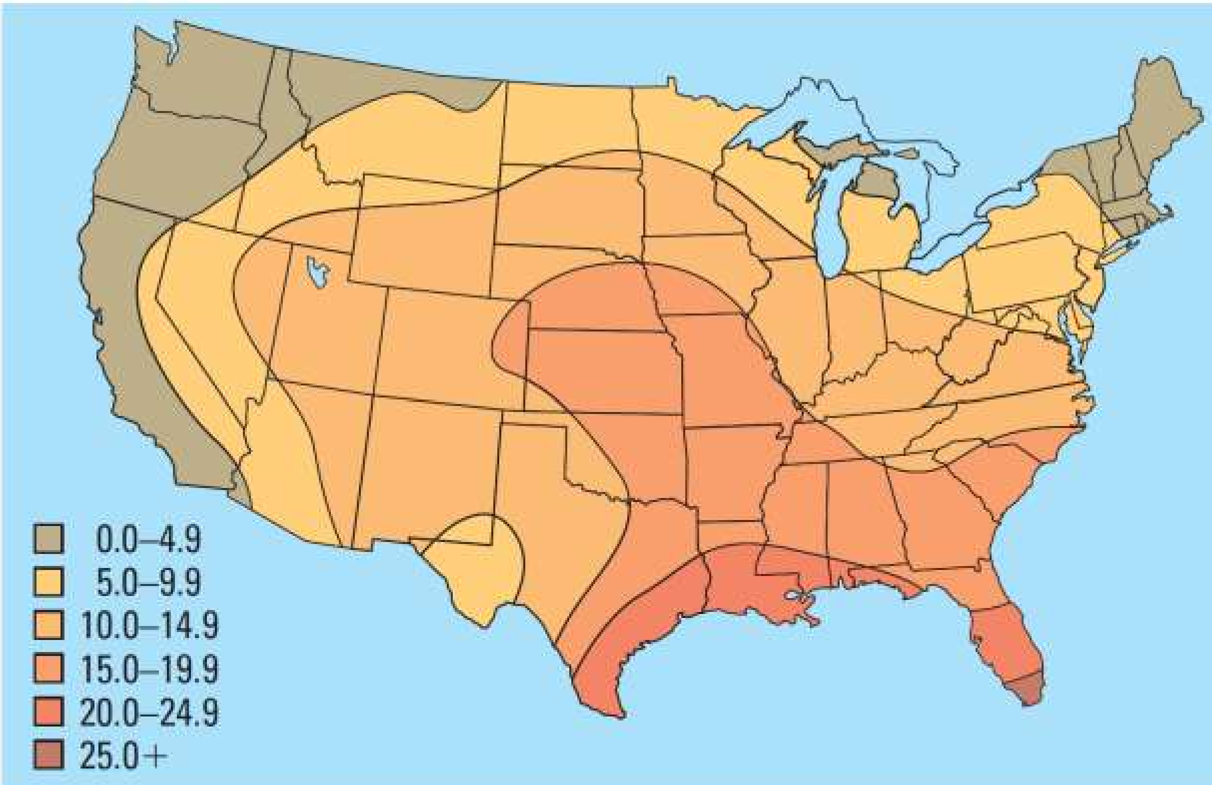
- Just like 88D, but its only purpose is to protect a specific airport by detecting downbursts and wind shear
- Located only 15-20 miles from the airport to better detect microbursts in small size (2-4 km diameter).
- Downburst-related aircraft accidents have decreased dramatically since the 1970s and 1980s.



Andrews AFB Downburst, 01AUG83



How common are microbursts?



Average number of potential microburst Days for the months of July and August

- Three field programs: NIMROD, 1978, northeastern IL; JAWS, 1982, Denver, CO; MIST, 1986, northern AL
- 50 microbursts in 42 days of MINROD, 186 in 86 days of JAWS, and 62 in 61 days of MIST-- > one microburst per day

Summary

- **Downbursts:** Convective downdrafts reaching the ground and spreading out.
  - Microbursts: < 4 km across
  - Can produce damaging surface winds
- Favored by (in addition to TR):
  - A large environmental lapse rate below the cloud
  - Dry air near the surface, can form from virga
  - Glaciated cloud
  - Unstable low-level lapse rate
- Hazard to (low altitude) aviation---Headwind followed by tailwind leads to stalls
- Radial toward-away couplet oriented parallel to the wind on Doppler radar

FOR NEXT TIME

- Final Exam Review