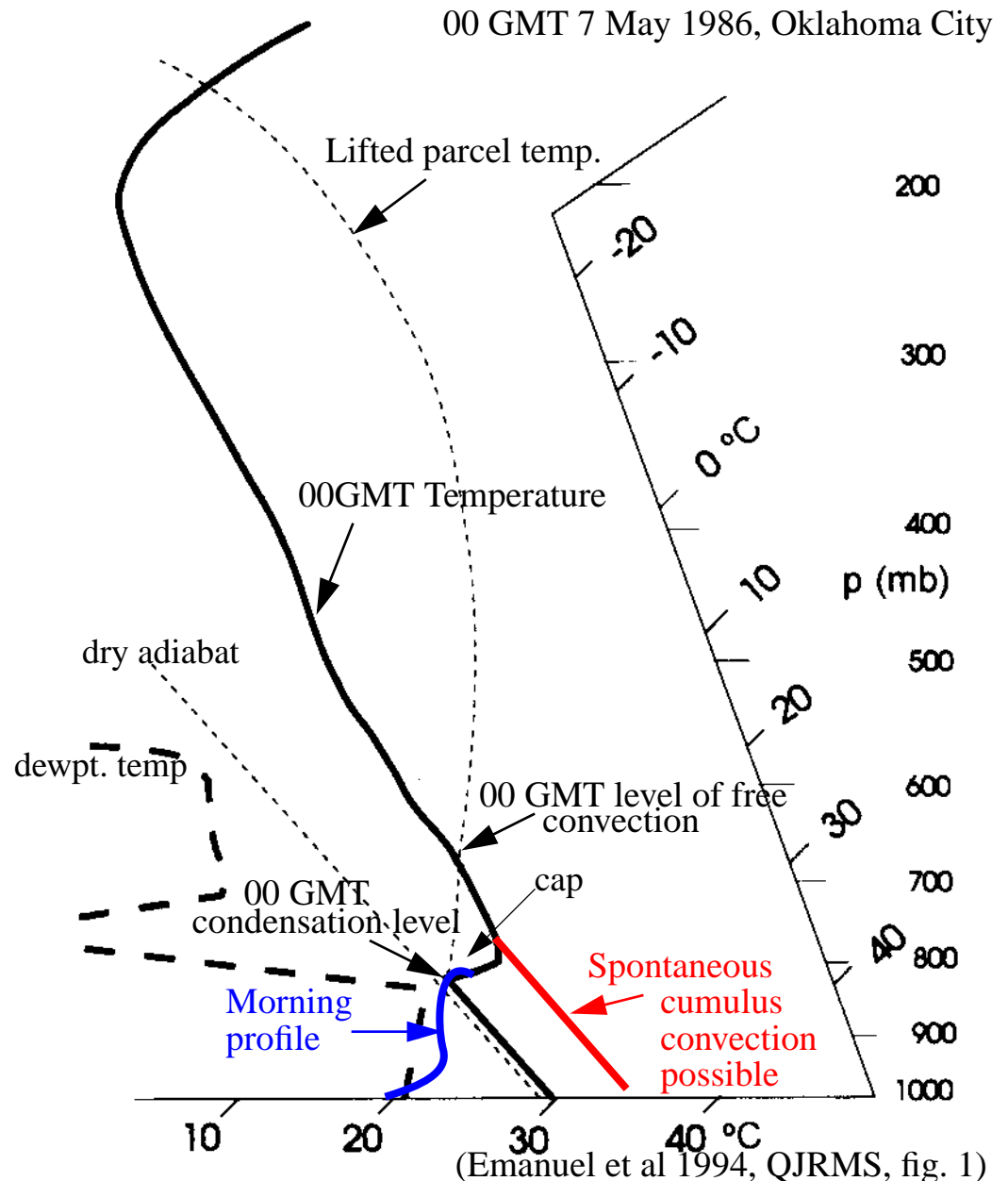


## Lecture 26 Thunderstorms

- Cumulonimbus that produce lightning/thunder.
- Charge separation requires vigorous updraft in which ice particles grow.
- Need a conditionally unstable layer several km deep aloft. Such a layer persists until...
- As surface warms, convection creates thermals.
- As thermals penetrate higher, they condense into cloud.
- When cloud-capped thermals are warm enough to penetrate into the conditionally unstable layer, T-storms rapidly develop

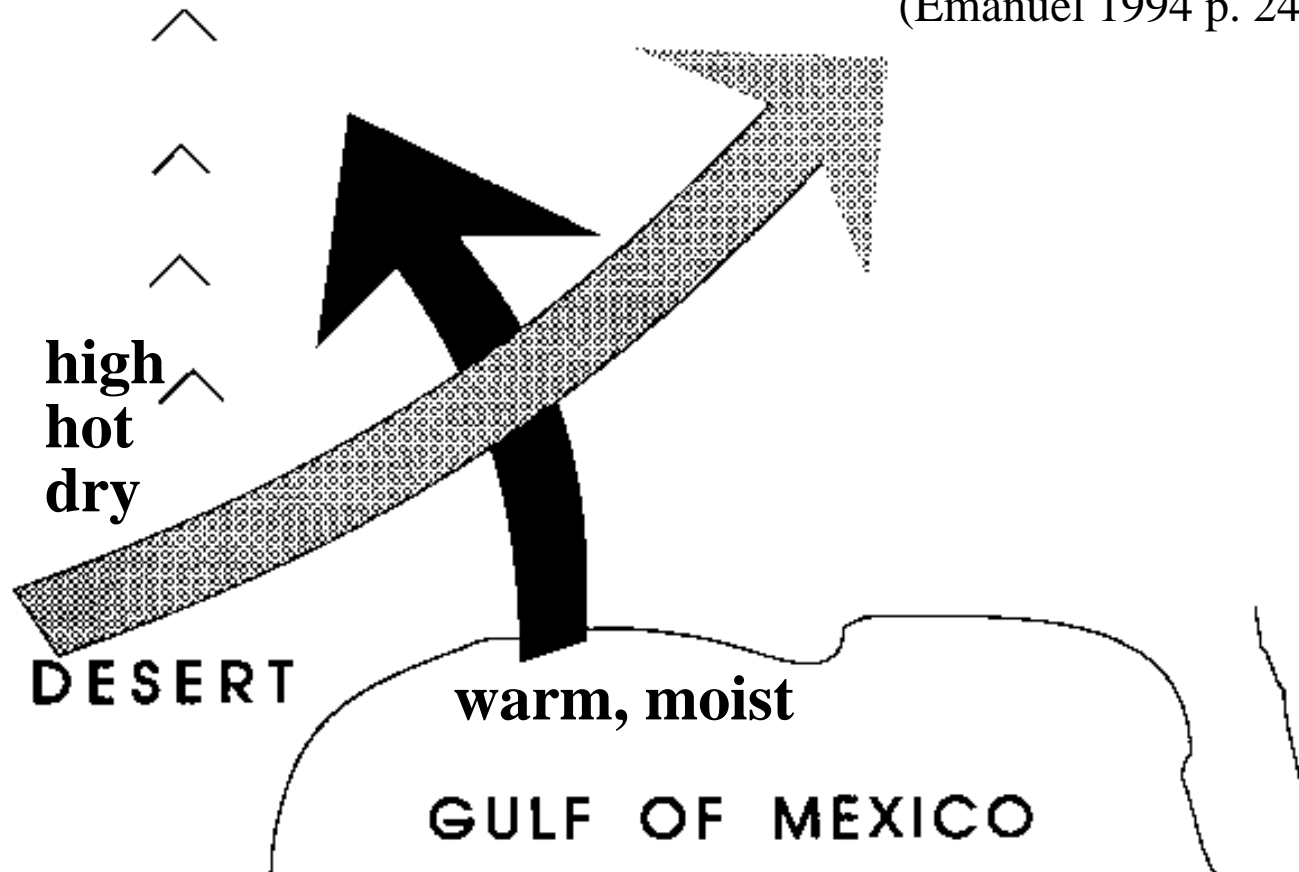
## Highly conditionally unstable profile

- Note 'cap' - inversion at 800-830 mb. All the air below this cap must be heated up by convection of warm air up from the land surface during the day before thunderstorms are possible.
- Once cumulus convection is possible, air parcels rising undiluted in cumuli could be 10 C warmer than ambient at 400 mb, producing enormous buoyancy and violently strong updrafts.



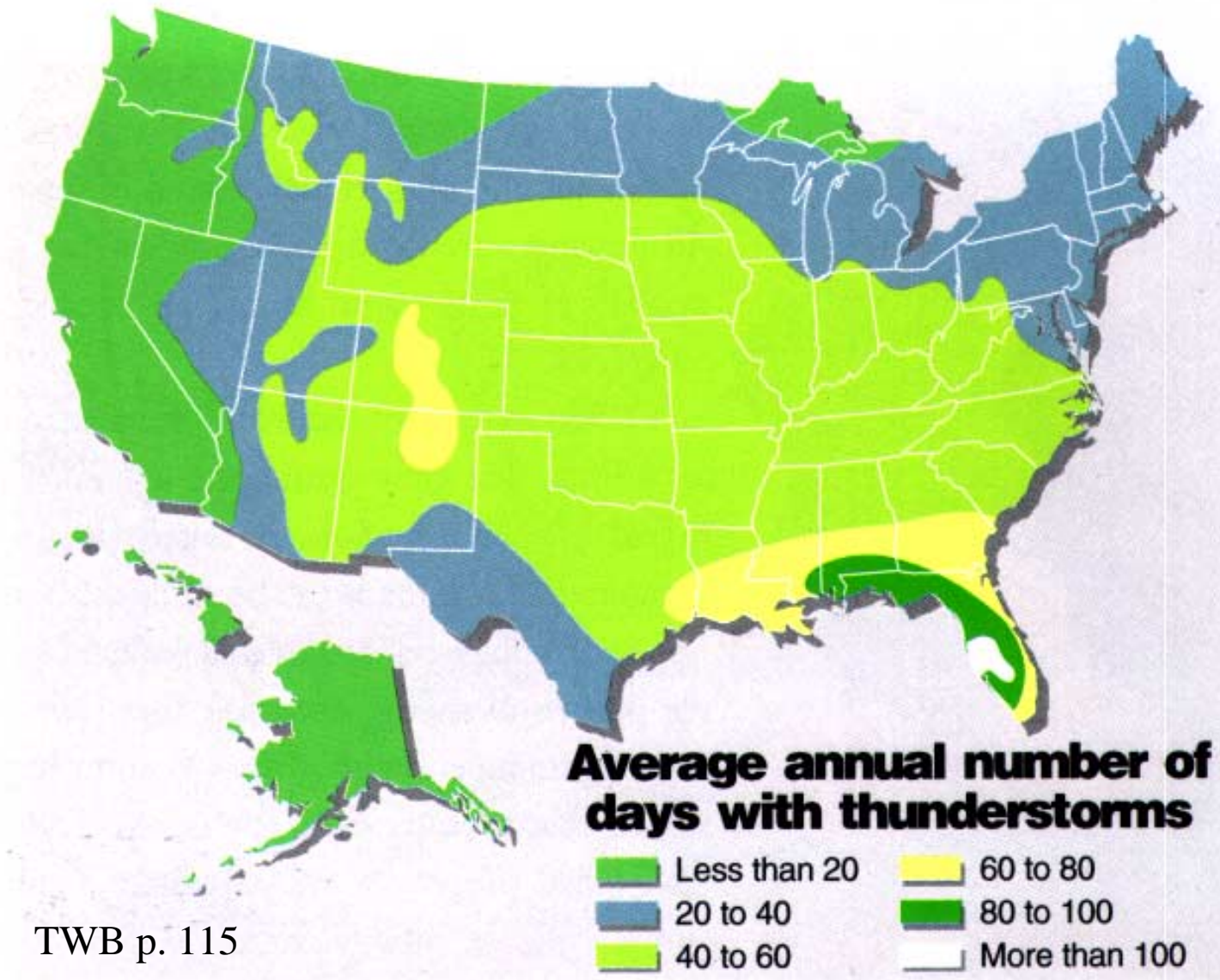
## Why severe thunderstorms in Midwest?

(Emanuel 1994 p. 242)



- Over deserts, intense sun creates deep, hot, dry convecting layer several km deep with dry-adiabatic stratification of 10 C/km (conditionally unstable)
- This air is blown over 1-2 km deep moist layer
- Severe T-storms form if moist air becomes warm enough to form cumuli that penetrate upper layer.

## Distribution of T-storms



TWB p. 115

Maxima: Florida (sea breeze), Southern Rockies, Midwest/Southeast

## **Types of T-Storms**

Single-cell

Multicell

Squall line

Mesoscale convective complex

Supercell

## **T-Storm Hazards**

Lightning

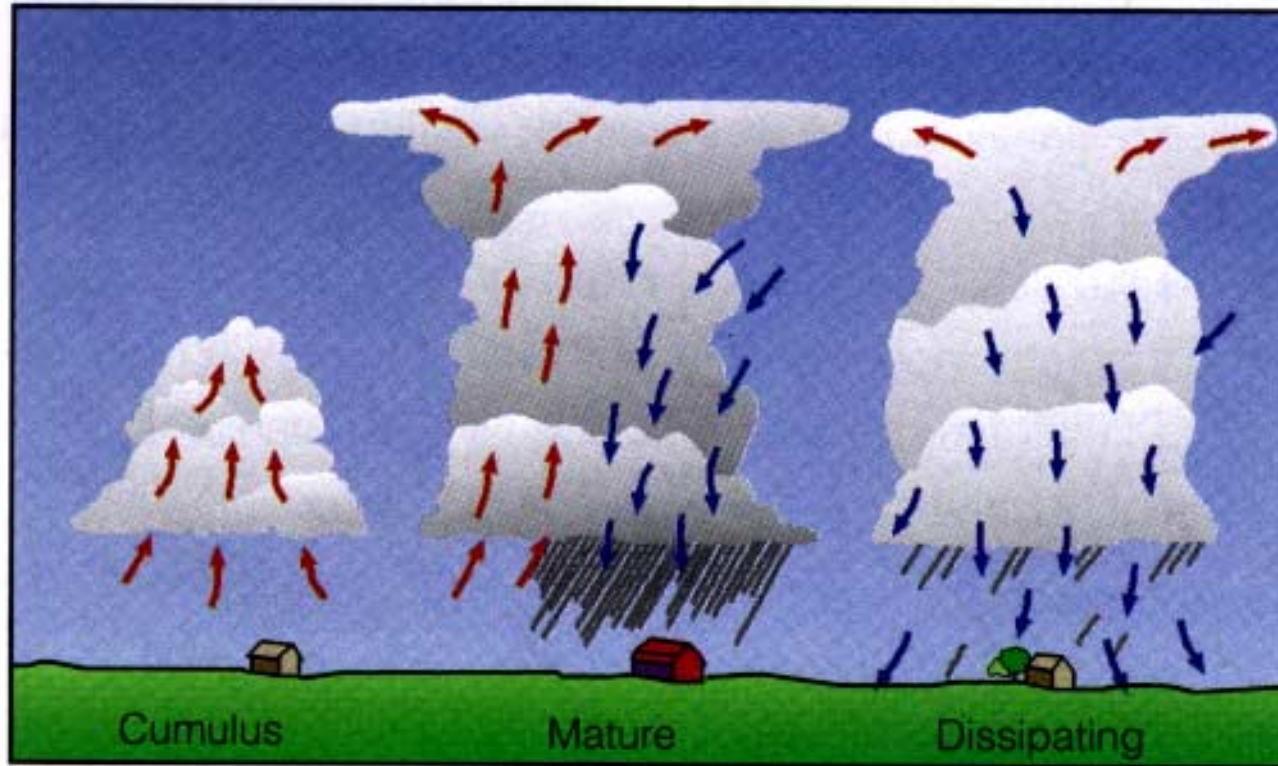
Flash floods

Hail

Strong winds

Tornadoes

# Single Cell Storms



**Figure 10.1** (EOM)

Simplified model depicting the life cycle of an air-mass thunderstorm that is nearly stationary. (Arrows show vertical air currents.)

- Form in warm air masses away from fronts, where winds are light at all levels.
- Typical updraft is 10 km across.
- Typical lifetime is 30-60 min.

## **Cumulus Stage**

- Single growing cloud-filled updraft
- Significant precip hasn't formed
- No downdraft.

## **Mature Stage**

- Large raindrops/ice particles fall from updraft
- They drag air down with them to form downdraft
- Weight of raindrops and cooling by evaporation of rain keep downdraft air heavy as it plummets to ground.
- Updraft reaches max height at top of conditionally unstable layer, spreads as anvil of ice crystals.

## **Dissipating Stage**

- Downdraft chokes off low-level updraft
- Low-level cloud evaporates to leave only anvil.

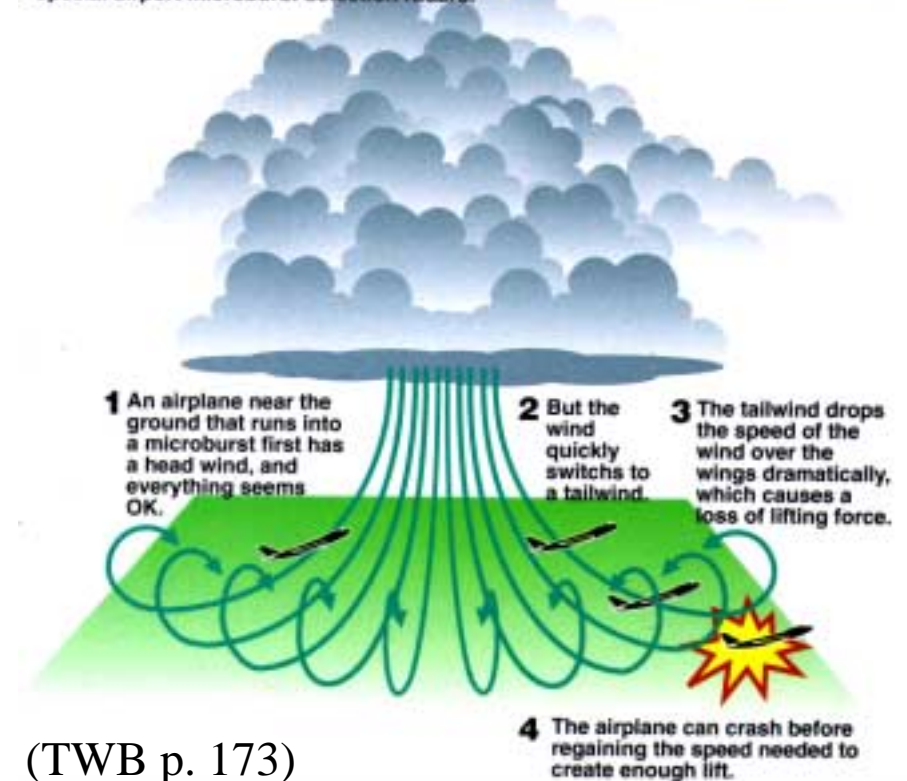


# Microbursts

- Rapidly sinking heavy downdraft air hits ground, spreads radially as a patch of high winds.
- Aviation hazard due to rapid wind shear.
- Dry microburst (Colorado) -high cumulus base, light rain from puny Cb evaporates into downdraft, and cold downdraft air 'free falls'
- Wet microburst (Southeast) - in very moist conditions, huge weight of suspended rain can smash downdraft into ground.

## What makes microbursts dangerous

A microburst is just one kind of wind shear — a sudden change in wind speed or direction — but it's dangerous to aircraft close to the ground. As awareness of the danger grew in the 1980s, pilots began receiving special training in avoiding microbursts and in coping with them. The United States government is also installing special airport microburst detection radars.



(TWB p. 173)



## Multicell storms



**Figure 10.3** EOM 10.4

A multicell storm. This storm is composed of a series of cells in successive stages of growth. The thunderstorm in the middle is in its mature stage, with a well-defined anvil. Heavy rain is falling from its base. To the right of this cell, a thunderstorm is in its cumulus stage. To the left, a well-developed cumulus congestus cloud is about ready to become a mature thunderstorm.

When winds aloft are 10-15 m/s different from surface, we often see clusters of cells, in which the cold air in downdraft from a mature cell wedges under and lifts surrounding air, triggering an adjacent new growing cumulus.