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?

• 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.

(Emanuel 1994 p. 242)
Distribution of T-storms

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

Average annual number of days with thunderstorms

- Less than 20
- 20 to 40
- 40 to 60
- 60 to 80
- 80 to 100
- More than 100

TWB p. 115
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**

- 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.

(TWB p. 173)
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.