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Lecture 11 – THUNDERSTORMS

11.1 GENERAL

- A *thunderstorm* is a storm that produces thunder and lightning
- Thunderstorms are associated with cumulonimbus clouds
- Thunderstorms are characterized by vigorous updrafts
- Thunderstorms require some lifting mechanism to start the initial upward motion
- This mechanism can be any one of the four lifting mechanisms that we discussed earlier in the first semester
  - Orographic lifting
  - Frontal lifting
  - Convergence lifting
  - Convective lifting
- Usually, several of these mechanisms work together to generate severe thunderstorms

11.2 THUNDERSTORMS

- The birth of a thunderstorm occurs when warm, humid air rises in a conditionally unstable environment
- A thunderstorm is a storm containing lightning and thunder, and sometime produces gusty winds with heavy precipitation and hail
- The lightning stroke can heat the air through which it travels to **30,000**^{o}C (**54,000**^{o}F), which is **5** times hotter than the surface of sun
- This extreme heating causes the air to expand explosively, thus initiating a shock wave that become a booming sound wave (**thunder**) to travel outward
- ***Lightning*** is an electrical discharge through the air, and ***thunder*** is the result of the explosive heating of air by the discharge
- ***Thunder*** takes **3** seconds for thunder to travel **1** km (**5** seconds to travel **1** mile)

11.3 STAGES OF DEVELOPMENT OF THUNDERSTORMS

- Extensive studies indicate that thunderstorms go through a cycle of development from birth to maturity to decay

11.3.1 Cumulus Stage

- As humid air rises, it cools and condenses into a single cumulus cloud or a cluster of clouds
- Only updrafts are present as air rises and adiabatically cools , as showing in figure (**11.1**) below

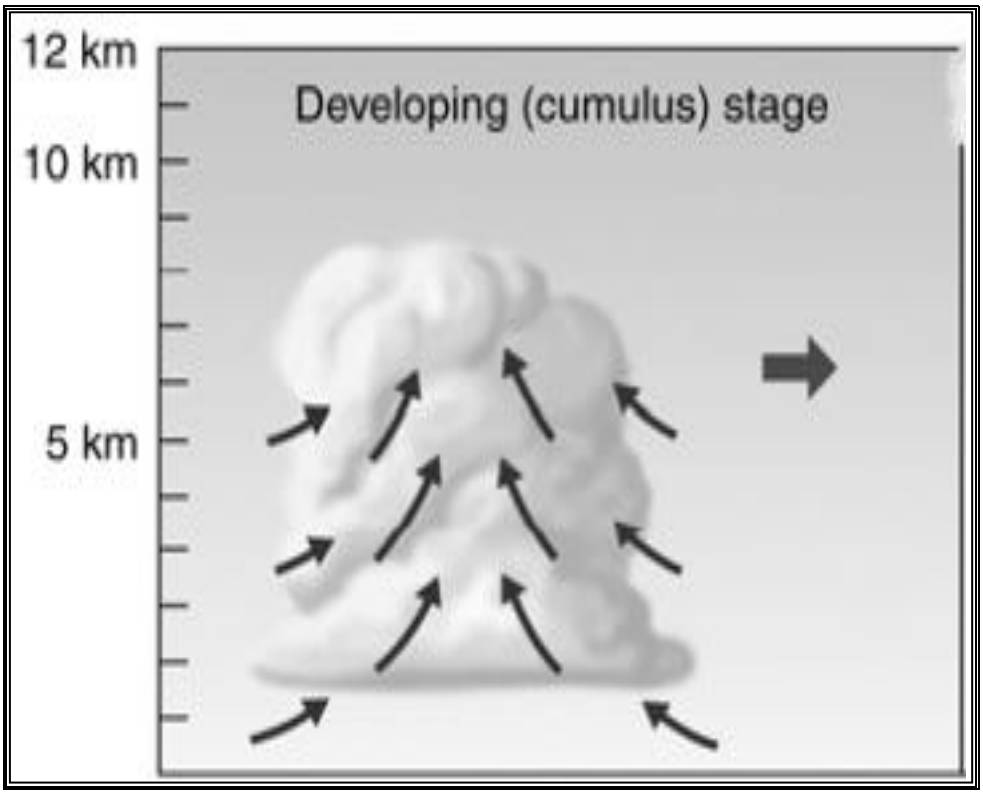

Fig.(11.1) : Developing stage of thunderstorm

- At first, the cumulus clouds grow upward only for a short distance, then they dissipate (because of re evaporation) as the drier air surrounding the cloud mixes with it
- Eventually, enough water vapor will be present to sustain vertical cloud development which occurs , and the cumulus cloud grows taller, often appearing as a rising dome or tower
- During the cumulus stage, there is no precipitation to form, and the updrafts keep water droplets and ice crystals suspended within the cloud, also there is no lightning or thunder during this stage
- As the cloud builds well above the freezing level, the cloud particles grow larger , they also become heavier
- Eventually, the rising air is no longer able to keep them suspended, and they begin to fall
- The air, now being colder and heavier than the air around it, begins to descend as a *downdraft*
- The precipitation beginning to fall, and the appearance of the downdraft marks that the storm enters its next stage

11.3.2 Mature Stage

- During its mature stage, the thunderstorm is most intense
- The cloud itself may extend upward to an altitude of over **12** km (**40,000** ft) and be several kilometers in diameter near its base , as showing in figure (**11.2**) below

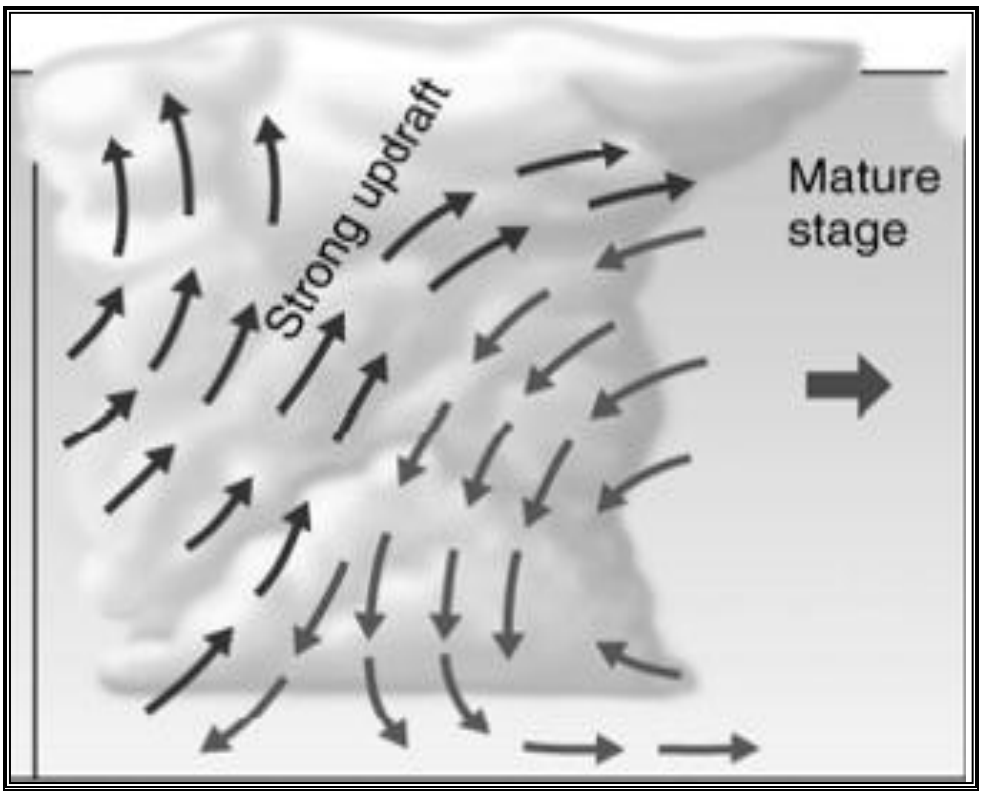

Fig.(11.2) : Mature stage of thunderstorm

- The ***mature stage*** is marked by the presence of both up and down drafts
- Lightning and thunder are also present in the mature stage
- Heavy rain (and occasionally small hail) falls from the cloud
- However, intense downdrafts from the storm may reach the surface, producing strong, gusty winds
- An anvil head may occur as high speed winds blow
- Updrafts dominate the interior portions of the storm while downdrafts occur toward the edges

11.3.3 Dissipative Stage

- The ***dissipating stage*** occurs when the updrafts weaken and downdrafts tend to dominate throughout much of the cloud , as showing in figure (**11.3**) below

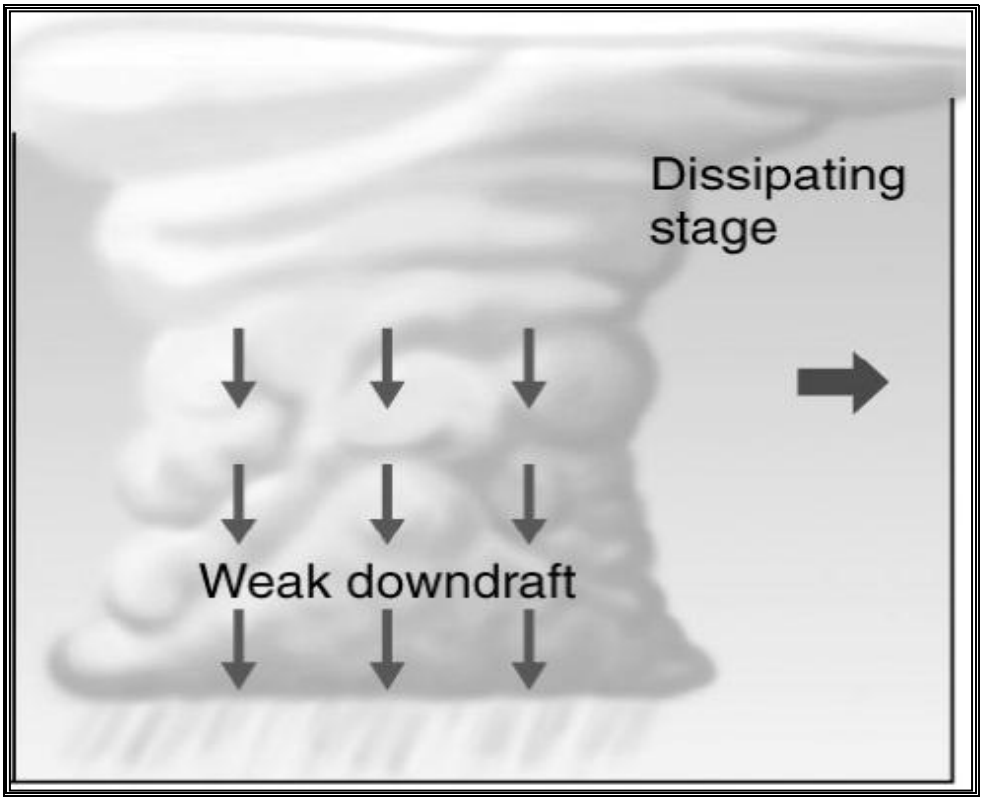

Fig.(11.3) : Dissipating stage of thunderstorm

- This suppresses updrafts and the addition of water vapor
- Precipitation then ceases and the cloud eventually evaporates
- An ordinary thunderstorm may go through its three stages in an hour or less
- The reason it does not last very long is that the storm's downdraft may cut off the storm's fuel supply by destroying the humid updrafts

11.4 OTHER CLASSIFICATIONS OF THUNDERSTORMS

- Thunderstorms are also classified according to the number and strength of the updrafts, or *cells* as shown in figure (**11.4**)
  - In a *single-cell* thunderstorm there is only one main updraft and downdraft
  - If there is more than one updraft present than we have a *multi-cell* thunderstorm
  - If there is a single, large updraft that is rotating then we have a *super-cell* thunderstorm
- The vertical profile of the winds determines whether the storm will be single-, multi-, or super-cell

***multi-cell* thunderstorm**

***super-cell* thunderstorm**

Fig.(11.4) : Other classifications of Thunderstorms

11.5 Distribution of Thunderstorms

- It is estimated that more than **40,000** thunderstorms occur each day throughout the world
- Hence, over **14** million occur annually
- Thunderstorms develop where moist air is forced aloft
- The combination of warmth and moisture make equatorial land masses especially conducive to thunderstorm formation
- Occurs frequently in the tropics, nearly daily in some locations
- Thunderstorms rarely occur in dry climates, such as the polar regions and the desert areas of the subtropical highs