

## Chapter 7, Part 2

### Cloud Development

---

---

---

---

---

---

## Cloud Formation

- Most clouds form as air rises, expands, and cools, causing water droplets to condense.
- The four basic mechanisms are
  - Surface heating and free convection
  - Topography
  - Widespread ascent due to convergence of surface air
  - Uplift along weather fronts

---

---

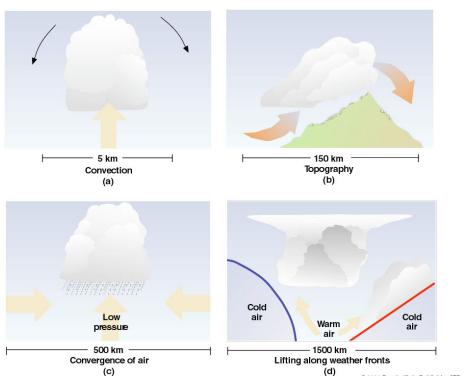
---

---

---

---

## Primary Mechanisms



---

---

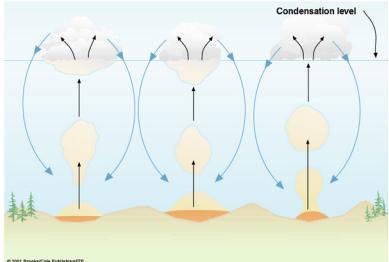
---

---

---

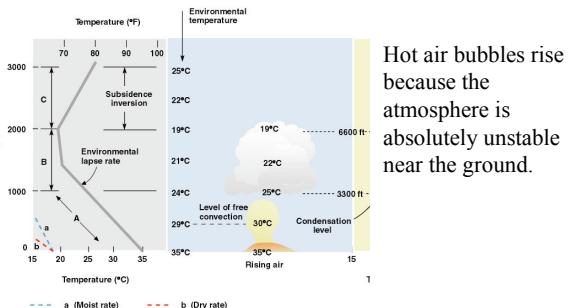
---

## Convection

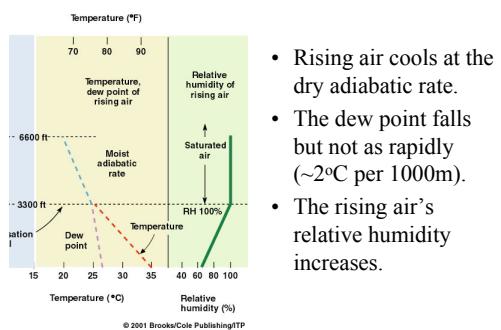


- Air over a hot spot rises, creating a hot air bubble.
- Colder heavier air returns.
- Blue sky visible between clouds.

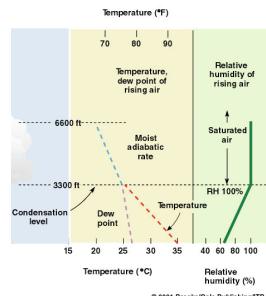
## 1. Development of a Cumulus Cloud



## 2. Development of a Cumulus Cloud

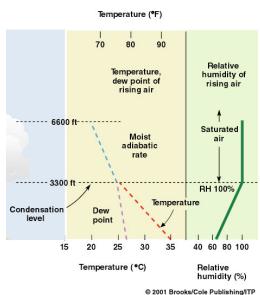


### 3. Development of a Cumulus Cloud



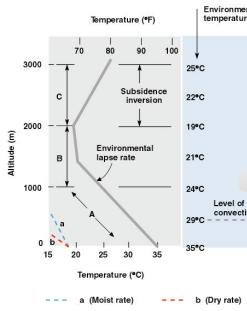
- Eventually the air has cooled to the dew point (100% humidity).
- Condensation begins and a cloud forms.
- This elevation is called the condensation level.

### 4. Development of a Cumulus Cloud



- The air continues to rise because it still warmer than the air outside the cloud.
- It now cools at the moist adiabatic rate since the air remains saturated.

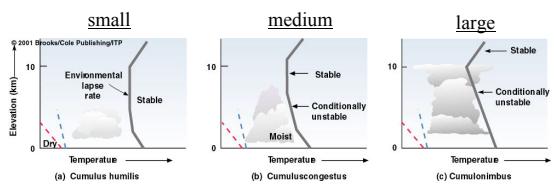
### 5. Development of a Cumulus Cloud



- The air stops rising when it reaches a stable region.
- This determines the cloud height.
- Clouds rarely extend very far above the tropopause since the stratosphere is stable.

## Stability and Cloud Height

Height of conditionally stable region:

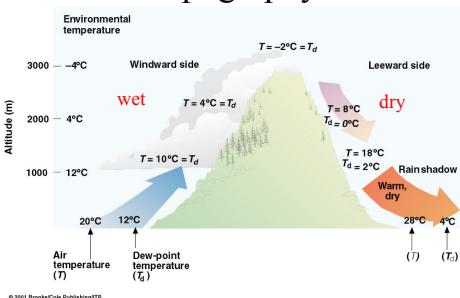


## Picture of Cumulus Clouds



- The cumulonimbus cloud with the anvil top has reached the stable part of the atmosphere.

## Topography



- Orographic uplift occurs when air is forced to rise to go over a large obstacle (mountain).

## 1. Formation of Orographic Clouds

- Air at base of mountain (0m) on windward side has  $T = 20^{\circ}\text{C}$  and a dew point of  $12^{\circ}\text{C}$ . The atmosphere is conditionally unstable.
- The air rises and cools at the dry adiabatic rate ( $10^{\circ}\text{C}$  per 1000m) and the dew point decreases at  $2^{\circ}\text{C}$  per 1000m.
- The air temperature reaches the dew point at 1000m (lifting condensation level). A cloud forms.

---

---

---

---

---

---

## 2. Formation of Orographic Clouds

- The air continues to rise except now at the moist adiabatic rate.
- At the top of the mountain the air temperature is still higher than the surrounding air so it continues to rise.
- The cloud remains on the windward side, but air is forced to descend the leeward side. It now descends at the dry adiabatic rate.

---

---

---

---

---

---

## 3. Formation of Orographic Clouds

- The air at the bottom of the mountain on the leeward side is warmer because it has descended at the dry adiabatic rate. The higher temperature is due to the latent heat released on the windward side.
- The dew point is lower because of the moisture removed from the air.

---

---

---

---

---

---

## Widespread Ascent and Fronts

- Air flowing together (convergence) will initiate lifting.
- Along a warm front, warm air gradually rides up and over colder surface air producing the uniform stratus like clouds.
- Along a cold front, warm moist air is forced up.
- Even in the absence of fronts warm air may form in regions of low pressure.

---

---

---

---

---

---

---

## Other Cloud Formation Mechanisms

- Changing cloud forms: Top of cloud cools and bottom warms by radiation making the cloud layer conditionally unstable. Stratus like clouds are converted to cumulus ones.
- Mixing: lower moist air mixes with colder dry air forming stratocumulus clouds.

---

---

---

---

---

---

---

## Summary

- Clouds form as warmer surface air rises, cools, and reaches saturation.
- The majority of clouds are created by one of four mechanisms:
  - Convection
  - Topography
  - Convergence of surface air
  - Weather fronts

---

---

---

---

---

---

---