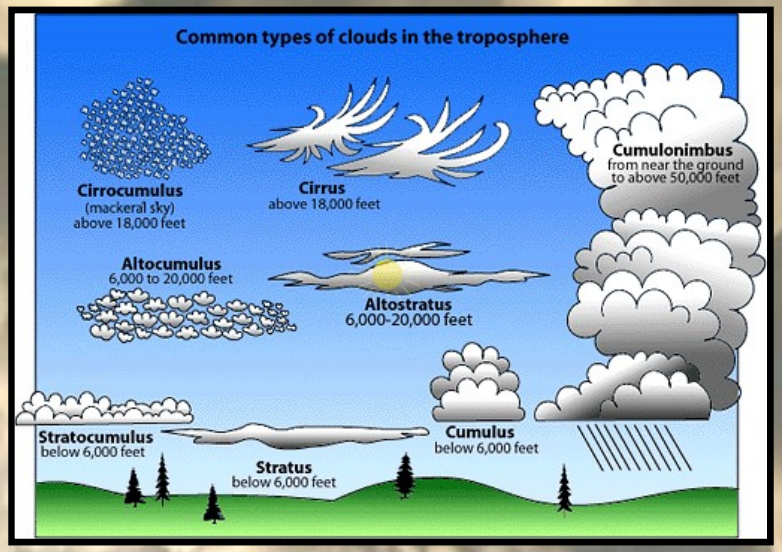
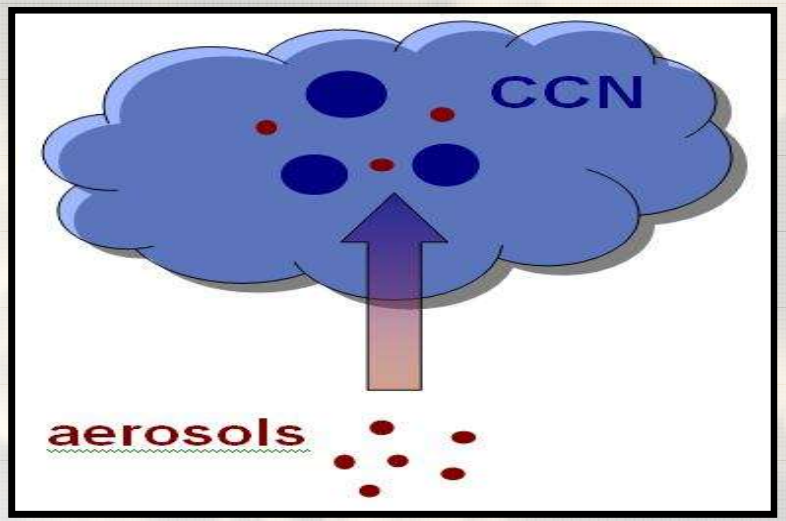
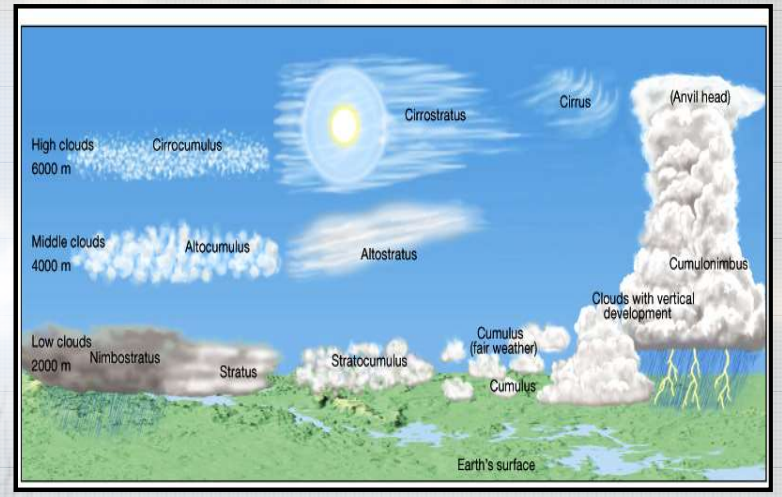


Lecture 8

Cloud Types & Fog

Learning Goals for Part 2 of Chapter 4





1. Be able to describe how a **CLOUD FORMS** and what the **THREE** important components.

2. Be able to identify the major **CLOUD TYPES**, their **ALTITUDE CLASS**, and if they are **LIQUID** or **ICE**.

3. Be able to identify and describe the different types of **FOG**.

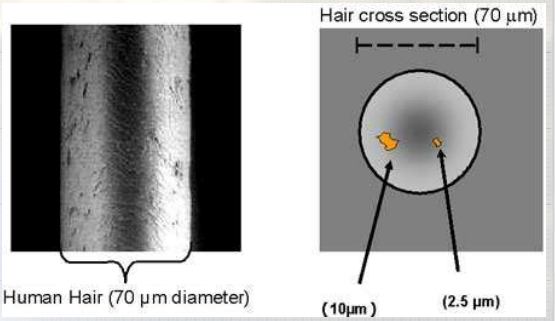
What is a cloud???

- A cloud can be defined as **any visible aggregate of tiny droplets of water or tiny ice crystals, or a mixture of both**.
  - They come in a variety of shapes and sizes
  - They are found at a large range of altitudes from the surface to the stratosphere
  - They are beautiful
  - They help meteorologists figure out what's going on in the atmosphere

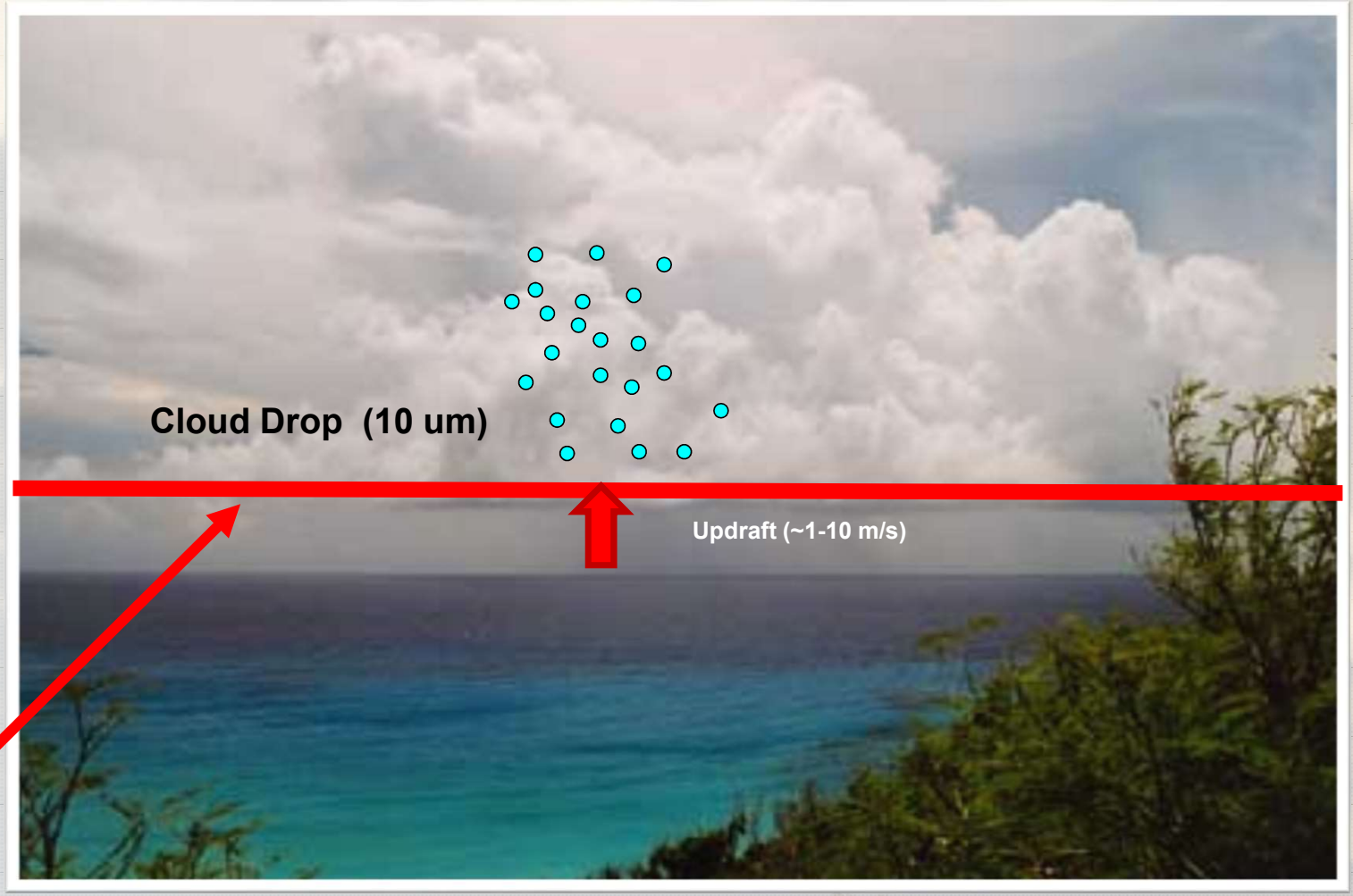
Continental Cumulus over rural Houston, Texas

Cloud Droplet Formation

- Cloud drops are, on average about 10 um in diameter.
- **For reference:** A human hair is about 70 um across.



Cloud Base
&
Lifted Condensation Level (LCL)

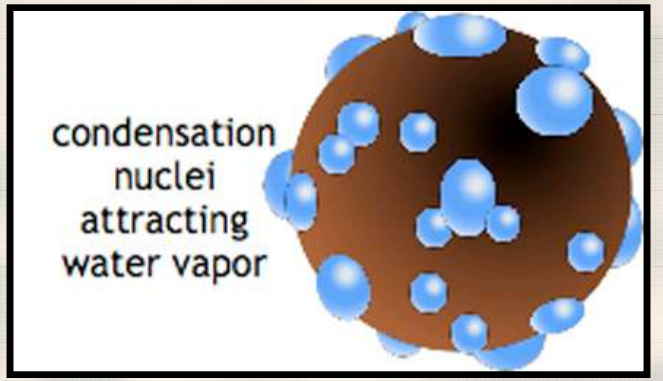


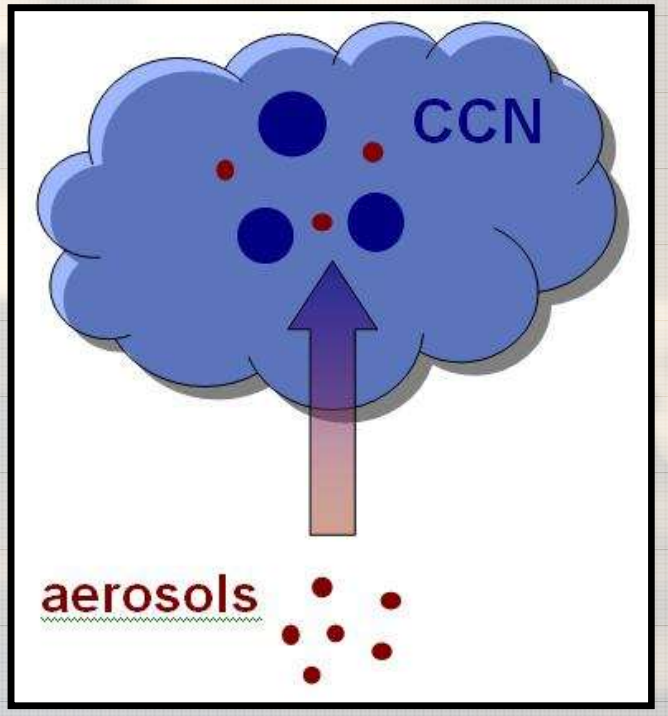
Recipe for a Cloud

1. **Cloud Condensation Nuclei (CCN)**
   - Serve as the surface for water vapor to condense upon

2. **Rising Air**
   - By one of the methods described last week.
   - Causes adiabatic cooling
   - Condensation occurs at the LCL

3. **Water Vapor**





Why do you need CCN?

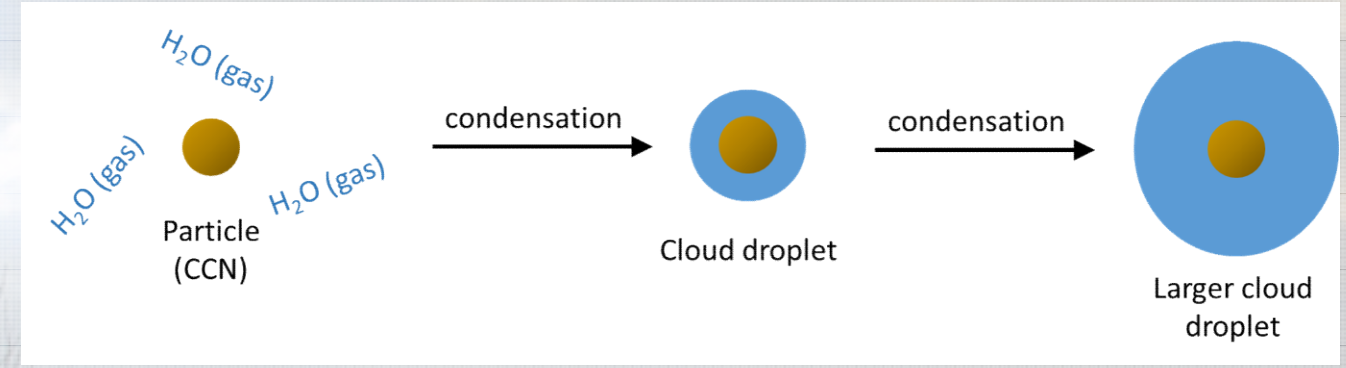
- The best particles are **hygroscopic** (water-seeking/liking) particles
  - Sea salt is a good example.

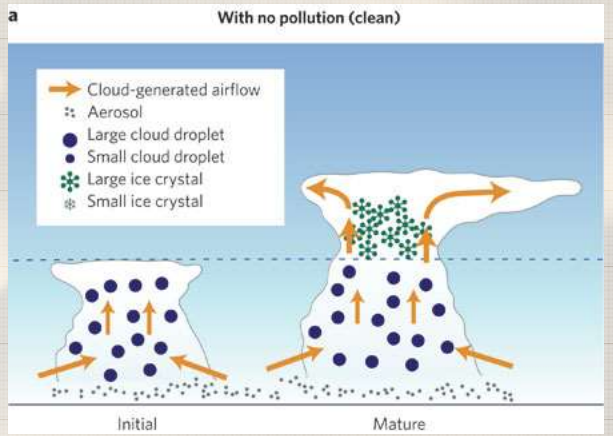
- **Hydrophobic** Particles (water repelling) can still serve as nuclei when RH is > or = 100%.

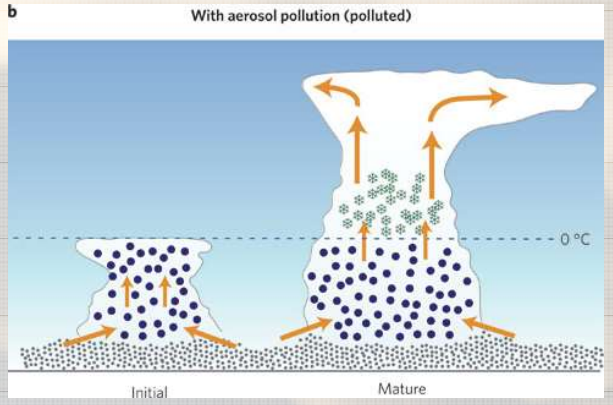
- Without CCN the RH would have to be **much greater than 100%** for a cloud drop to form.

Why are cloud drops so TINY?!

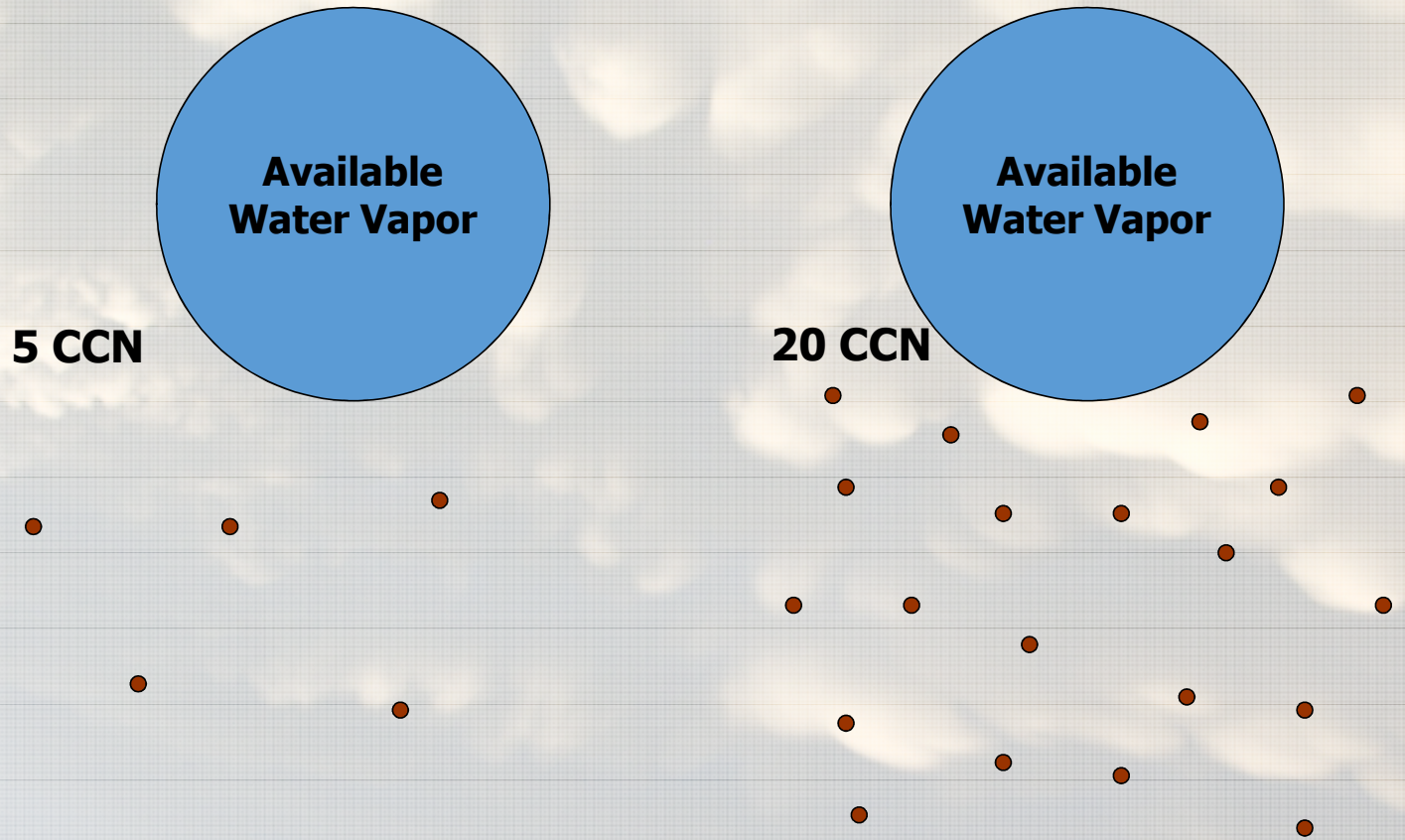
- Initially the drops grow really **FAST**
- But…. Lots of other aerosol **WANT** water too…
- So the water vapor is **split up over a lot of little drops** instead of a few big ones.



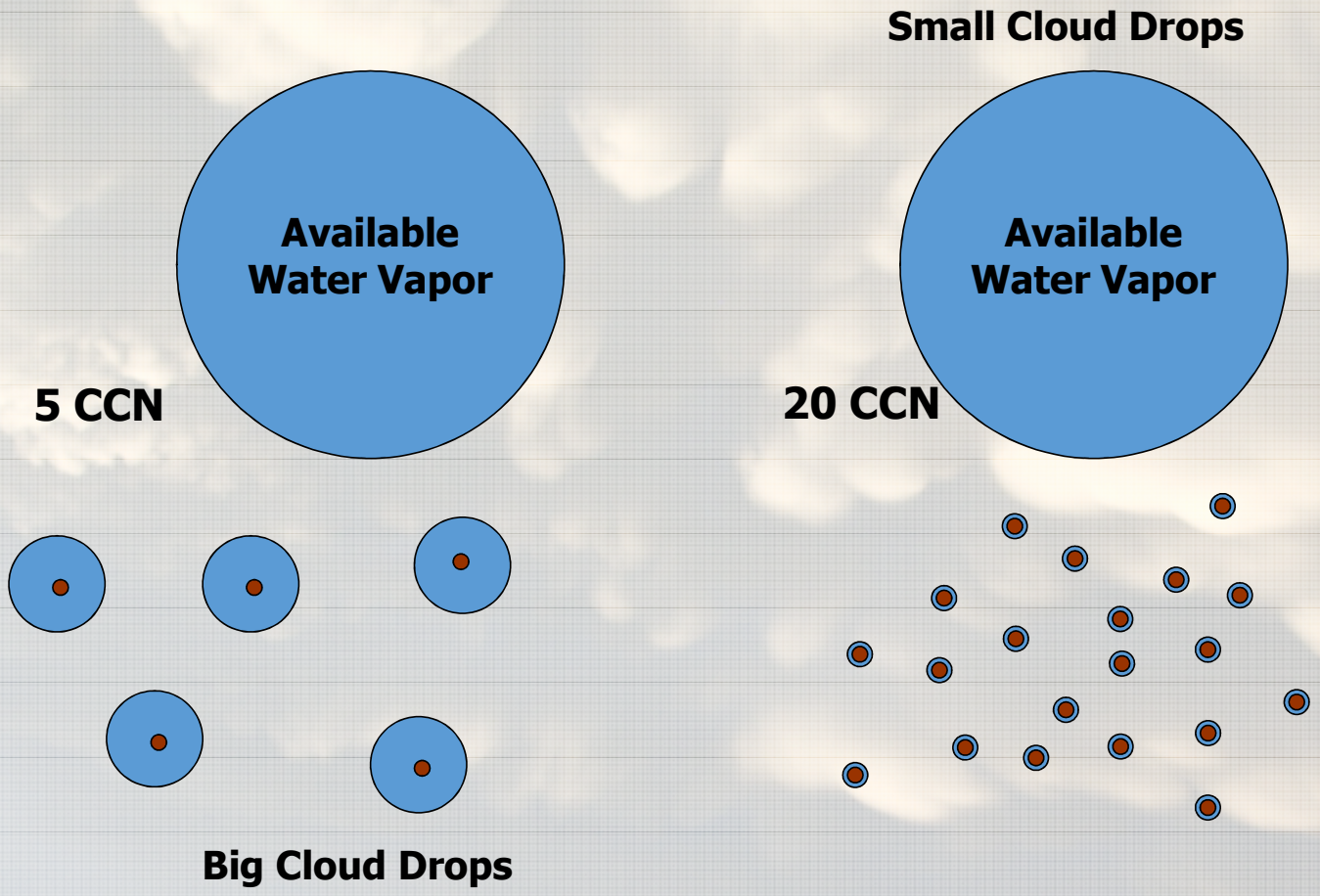




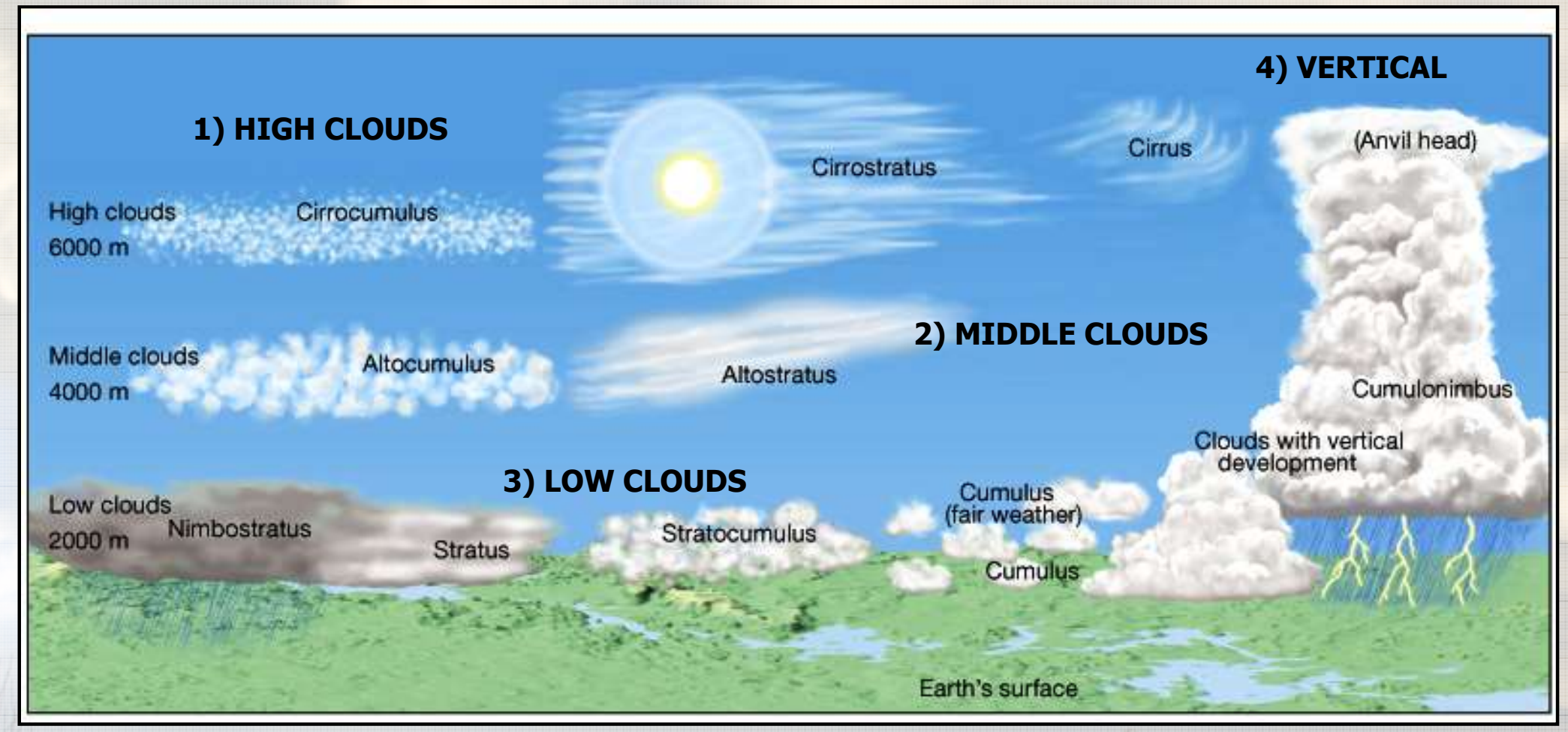
Why are cloud drops so TINY?!



Why are cloud drops so TINY?!



Cloud Classification



High Clouds

- **Cirrus**
  - Fibrous, “mare’s tails”
- **Cirrostratus**
  - White, produces halo
  - Approach of warm front
- **Cirrocumulus**
  - White, small cells or ripple
  - looks like “Fish Scales”
- Above 6000 m (20,000 ft)
- **ICE ONLY**
- No Significant Precipitation






Middle Clouds

- **Altocumulus**
  - Large patches of rounded masses or rolls
  - Usually water droplets
- **Altostratus**
  - Formless layer of grey cloud cover
  - Sun is only visible as a bright spot.
  - NO Halos
- Between 2000-6000 m (6,500-20,000 ft)
- **Mostly Water**
- Infrequently Precipitates Snow or Drizzle

JPL – Pasadena, CA

Beach in Long Island, NY

Low Clouds

- **Stratus**
  - Uniform layer covering most of sky
  - Sometimes precipitation
- **Stratocumulus**
  - Scalloped bottom, covering most of sky
  - Long parallel rolled or blobs
- **Nimbostratus**
  - Chief precipitation producers
  - light but for a long time
  - Associated with Stable conditions
- Below 2,000 m (6,500 ft)
- **LIQUID ONLY**






RAIN FALLING

Clouds of Vertical Development

- **Cumulus**
  - Individual masses that develop into vertical domes or towers
  - Tops often resemble cauliflower
  - Form on clear days

- **Cumulonimbus**
  - When Cumulus grow out of control
  - Dark, dense, billowing clouds
  - **VERY TALL** 12-20 km (7-12 miles)

- Bases are low (below 2,000 m) Tops up to 20 km!!
- **Water at the base, can have ice if they grow tall enough (into cold air)**
- Related to **unstable** air

Cloud Varieties – Additional Types

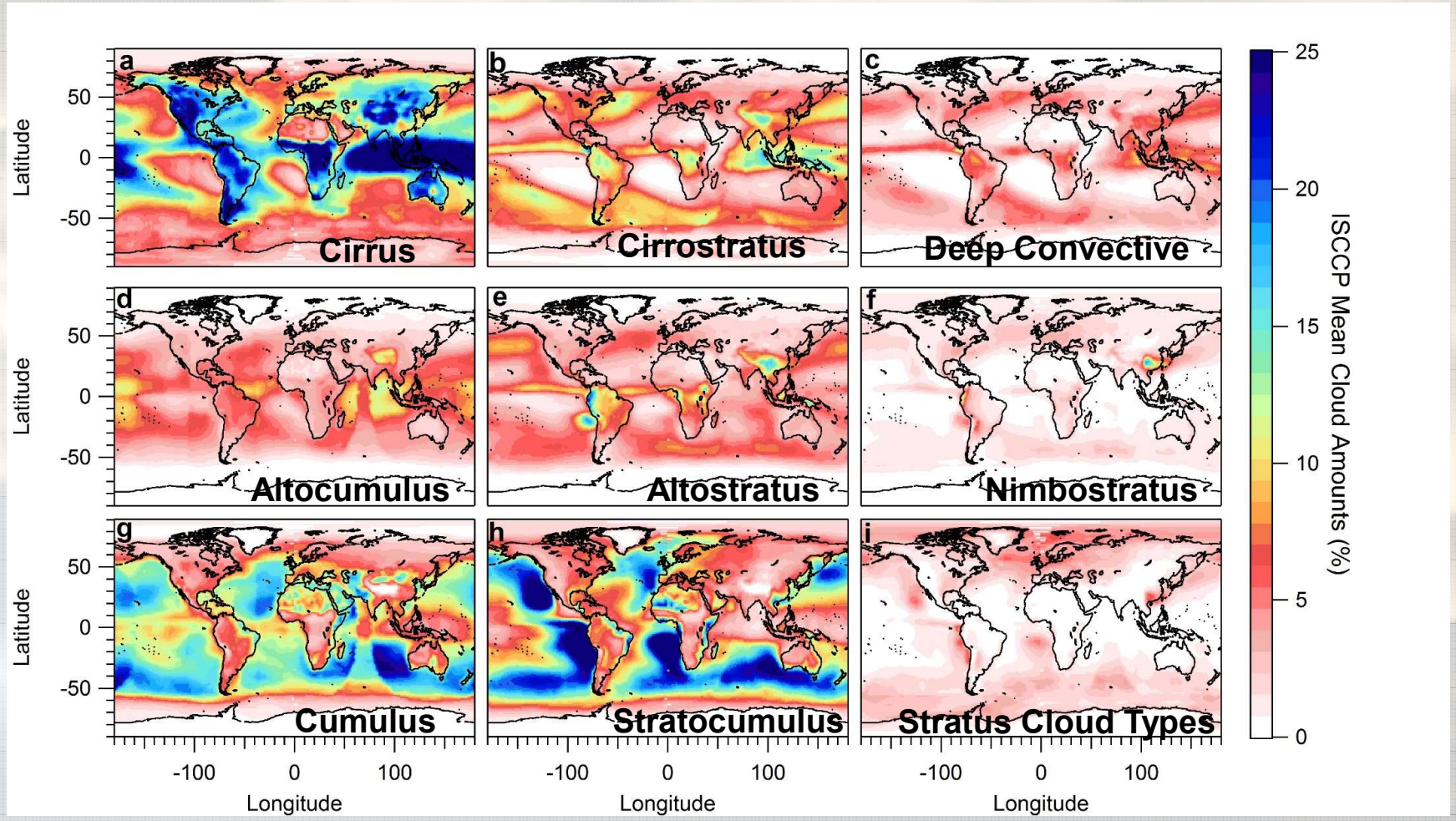
- **Mammatus**
  - Looks like udders
  - Happen after/before severe weather or Thunderstorms

- **Lenticular**
  - Looks like lentils or lenses
  - Most often seen near mountains

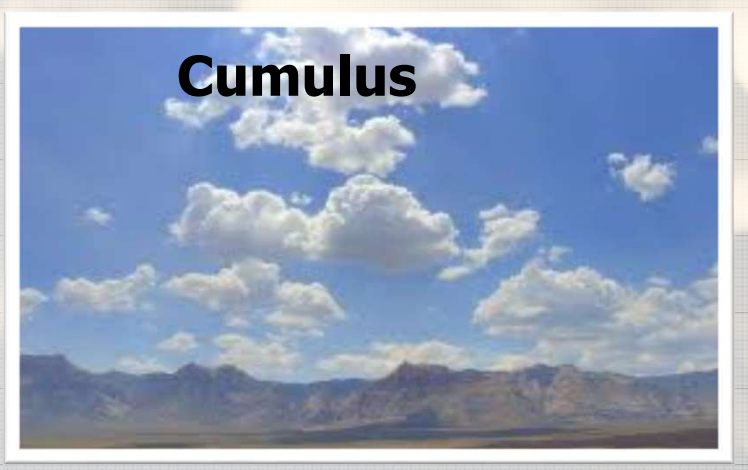
Cloud Type Summary Table

Cloud Family & Height	Cloud Type (abbreviation)	Info
High Above 6000 m	Cirrus (Ci)	Thin delicate filaments, ICE crystals, whispy
	Cirrostratus (Cs)	Thin white sheet, ICE crystals, produce halos around sun and moon
	Cirrocumulus (Cc)	Thin white, ICE crystals, and look like fish scales
Middle Between 2000-6000 m	Altocumulus (Ac)	White to grey, blob like… though widespread
	Altostratus (As)	Thin veil of clouds, may see sun as a disc but no halos
Low Below 2000 m	Stratus (St)	Low uniform layer, resembling fog, may produce drizzle
	Stratocumulus (Sc)	Soft, grey clouds, blobs and batches or rolls.
	Nimbostratus (Ns)	Dark grey amorphous clouds, RAIN producers
Vertically Developed	Cumulus (Cu)	Have flat bottoms, fair weather, billowy, cauliflower tops
	Cumulonimbus (Cb)	Towering clouds, sometimes form anvil heads, Heavy rainfall, hail, lightning, thunder and tornadoes

Clouds in the Climate System



NAME THAT CLOUD



Types of Fog

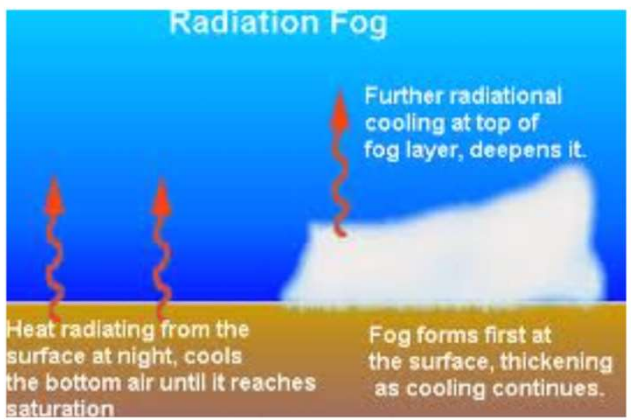
- **FOG** = a cloud with its base at or very near the ground.

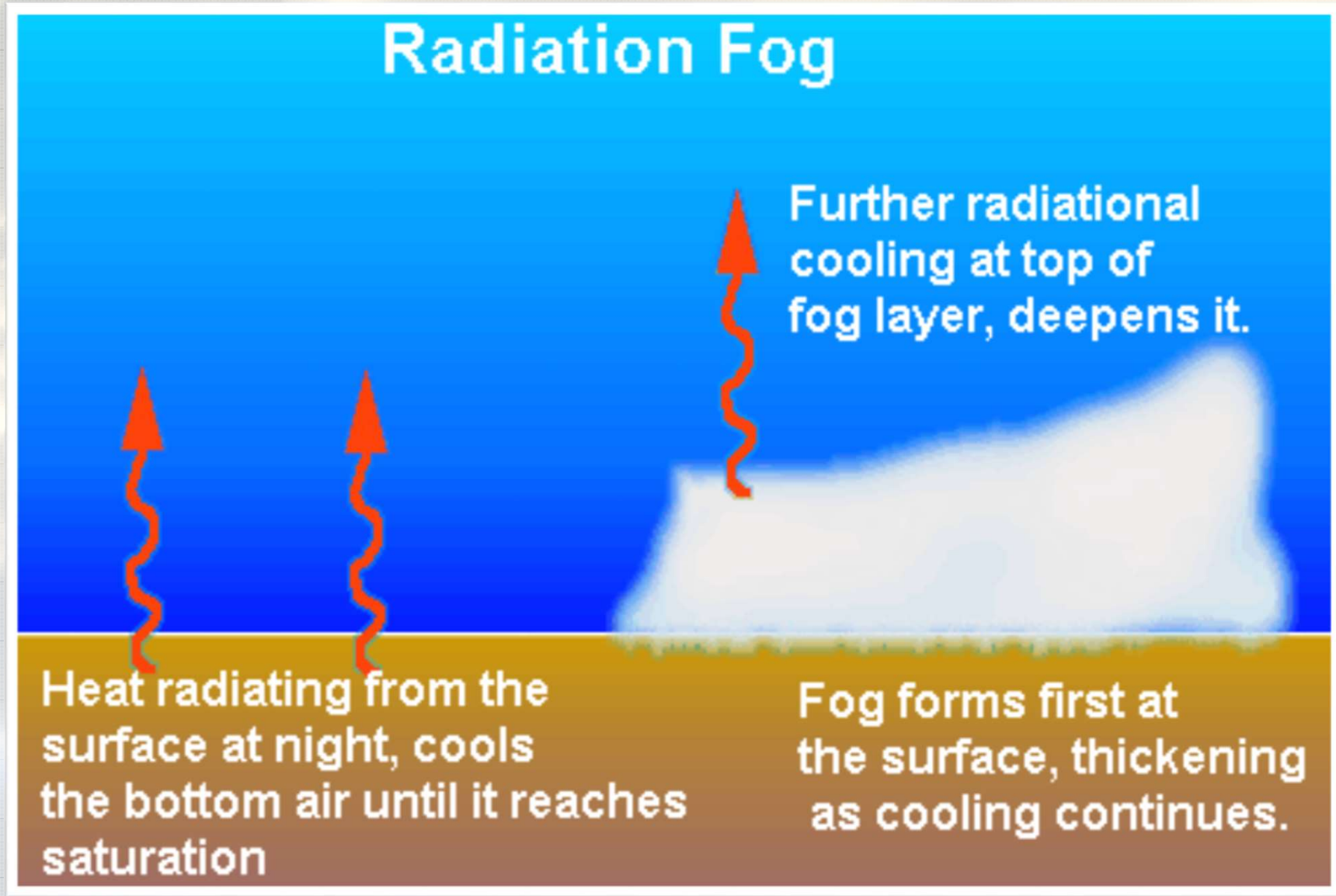
- **Fogs formed by Cooling**
  - Radiation Fog
  - Advection Fog
  - Upslope Fog

- **Fogs formed by Evaporation**
  - Steam Fog
  - Frontal Fog

Fogs Formed by Cooling

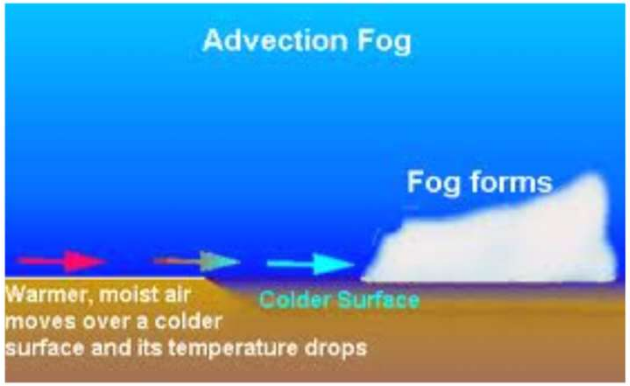
- **Radiation Fog**
  - The ground cools the air close to the surface
  - A night time phenomenon
  - Clear Skies
  - Fairly high RH
  - Cold air sinks in valleys
  - Dissipate after sunrise

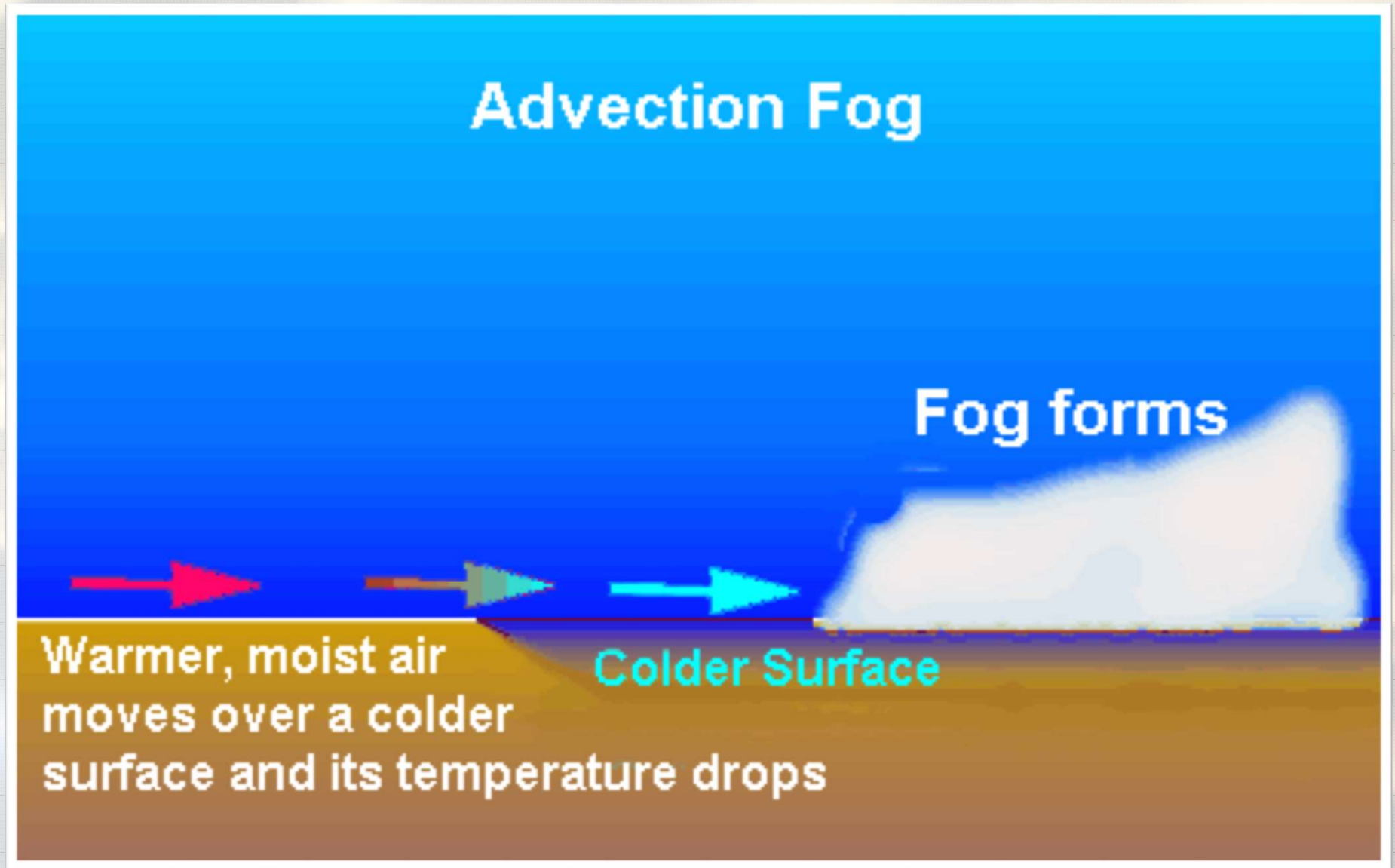



Radiation Fog
Further radiational cooling at top of fog layer, deepens it.
Heat radiating from the surface at night, cools the bottom air until it reaches saturation
Fog forms first at the surface, thickening as cooling continues.

Fogs Formed by Cooling

- **Advection Fog**
  - Warm moist air is blown over a cold surface
  - Advection = horizontal movement
  - Turbulence (wind) is needed to make it thick
  - Pacific Ocean near CA…. Cold current.. Warm air … Fog in SF and LA

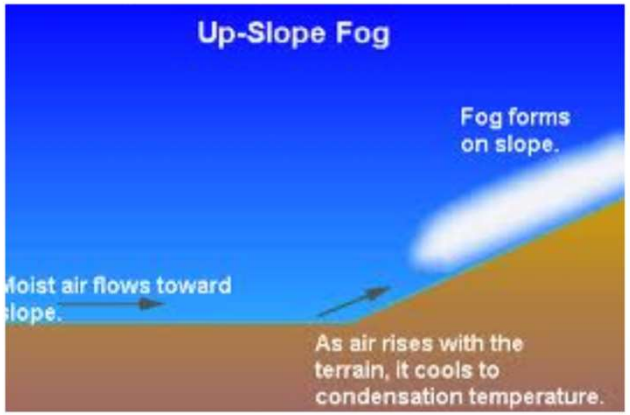


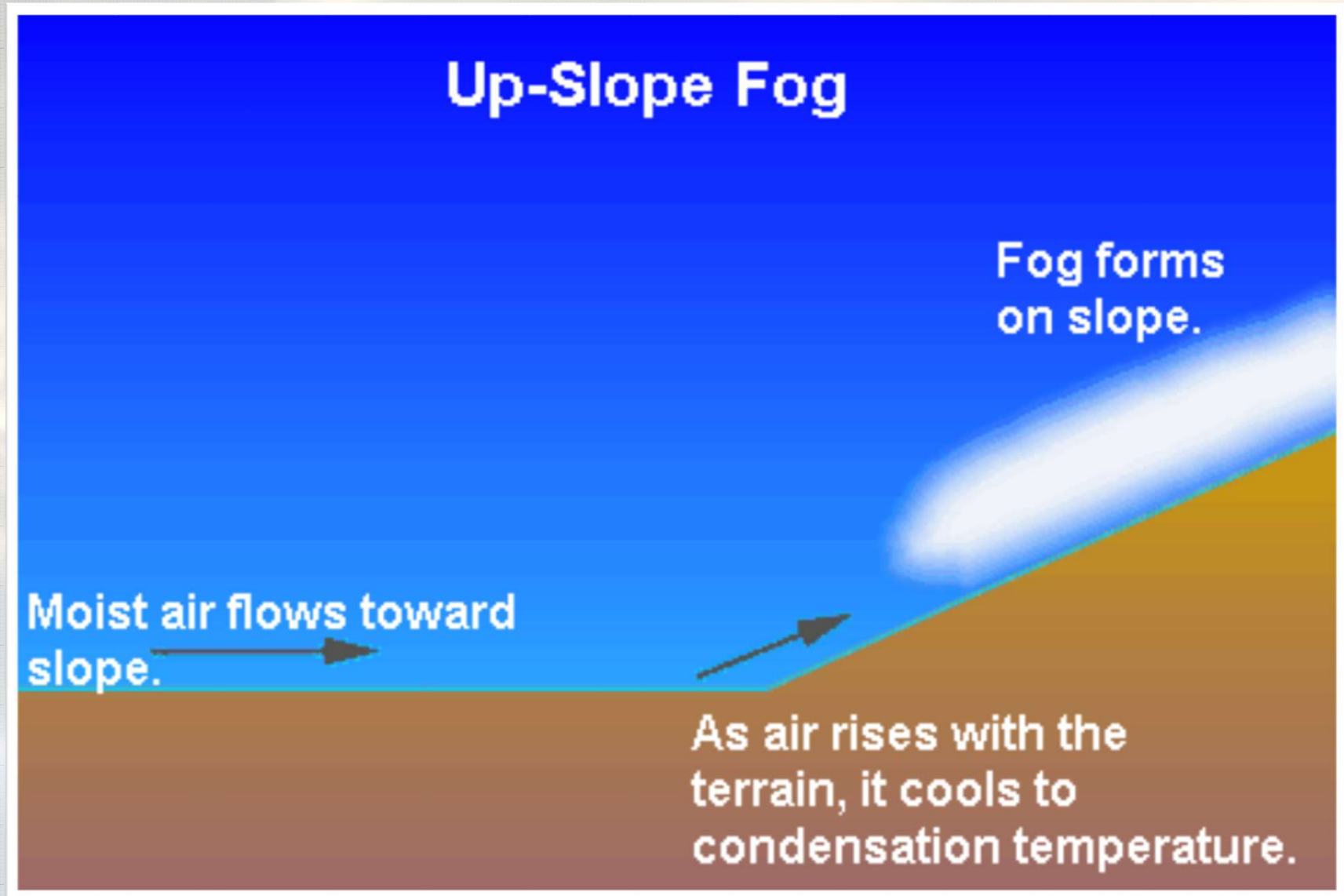

Advection Fog
Fog forms
Warmer, moist air moves over a colder surface and its temperature drops
Colder Surface

Fogs Formed by Cooling

- **Upslope Fog**
  - Humid air moves up a gradual sloping plain or mountain
    - As it moves up it cools… if to dew point you get fog

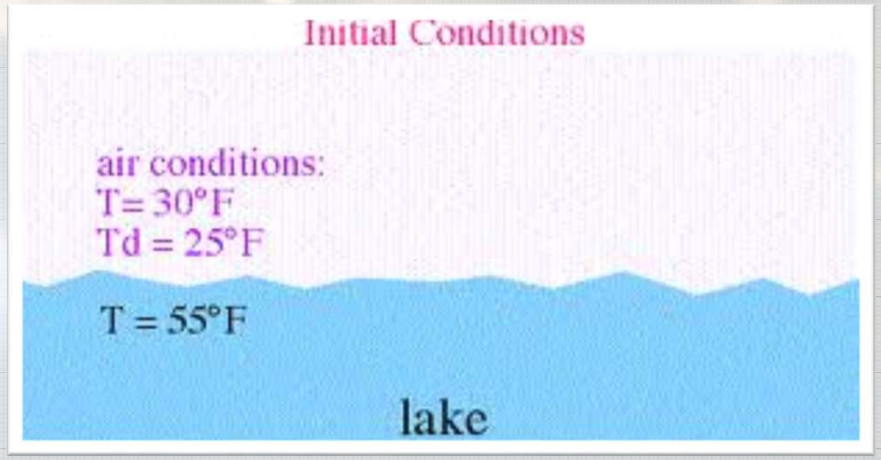
- **Ex: Great Plains**
  - Moist air from Gulf moves up towards the Rockies

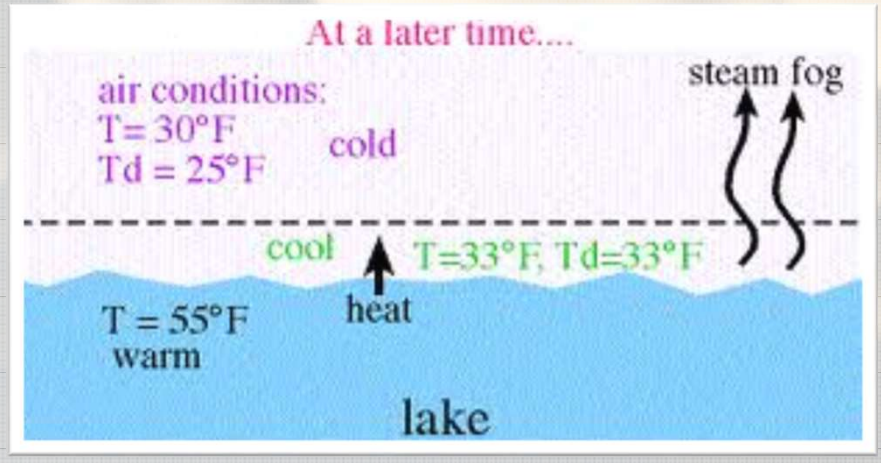



Up-Slope Fog
Fog forms on slope.
Moist air flows toward slope.
As air rises with the terrain, it cools to condensation temperature.

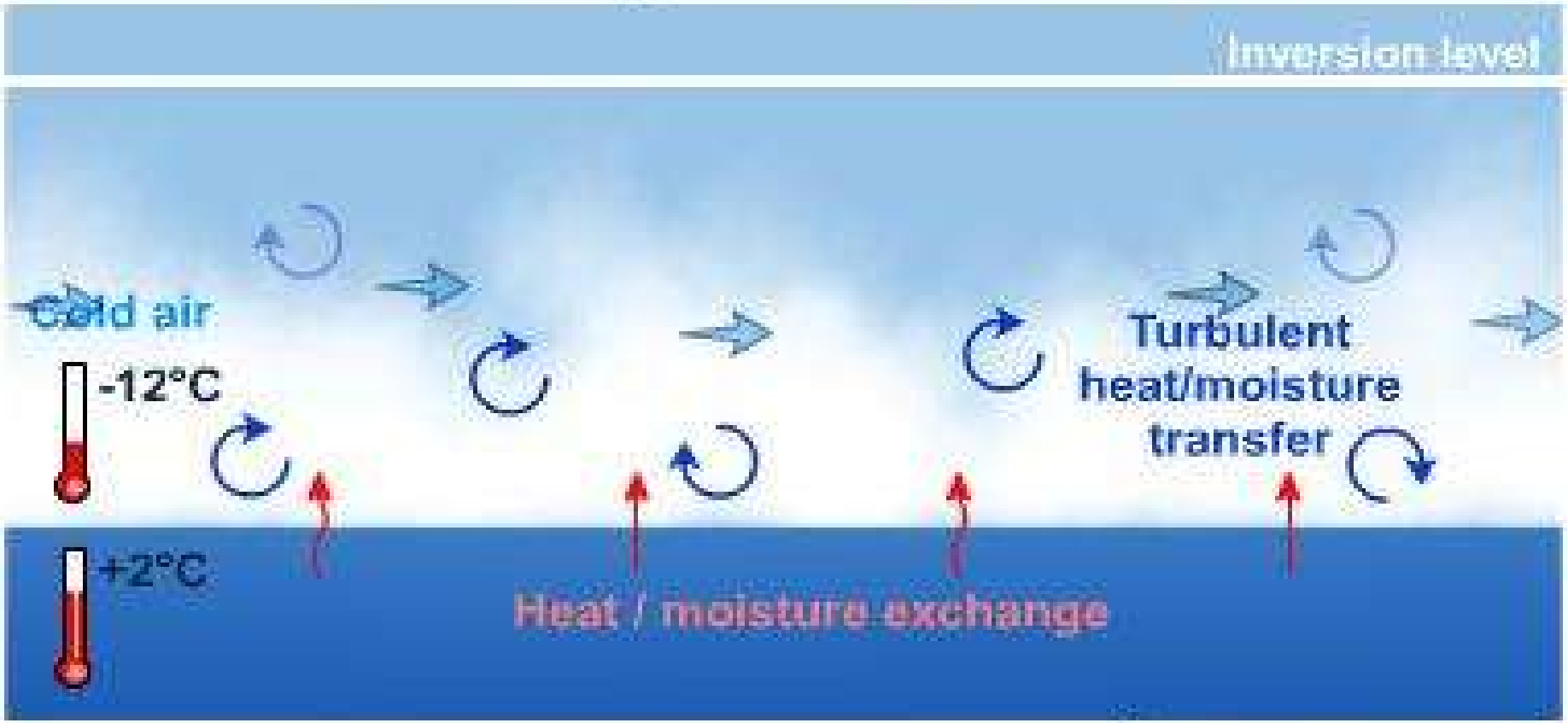
Fogs Formed by Evaporation

- **Steam Fog**
  - Cool air moves over warm water
  - Rising air cools and condenses
  - Moister added into the layer!!!!



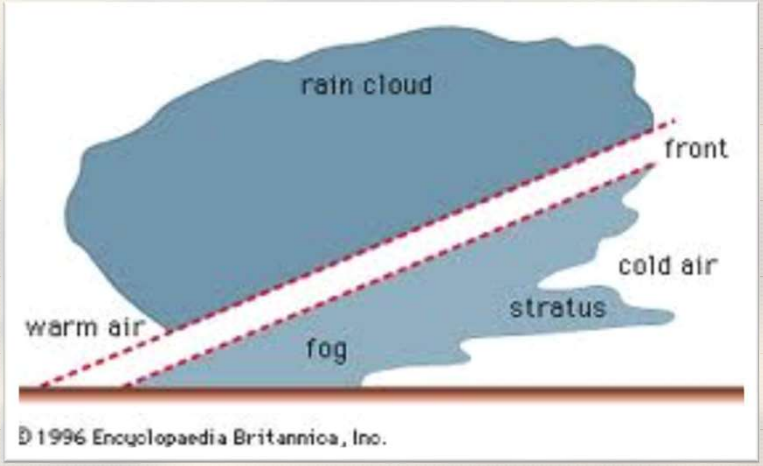


Steam Fog Formation Process

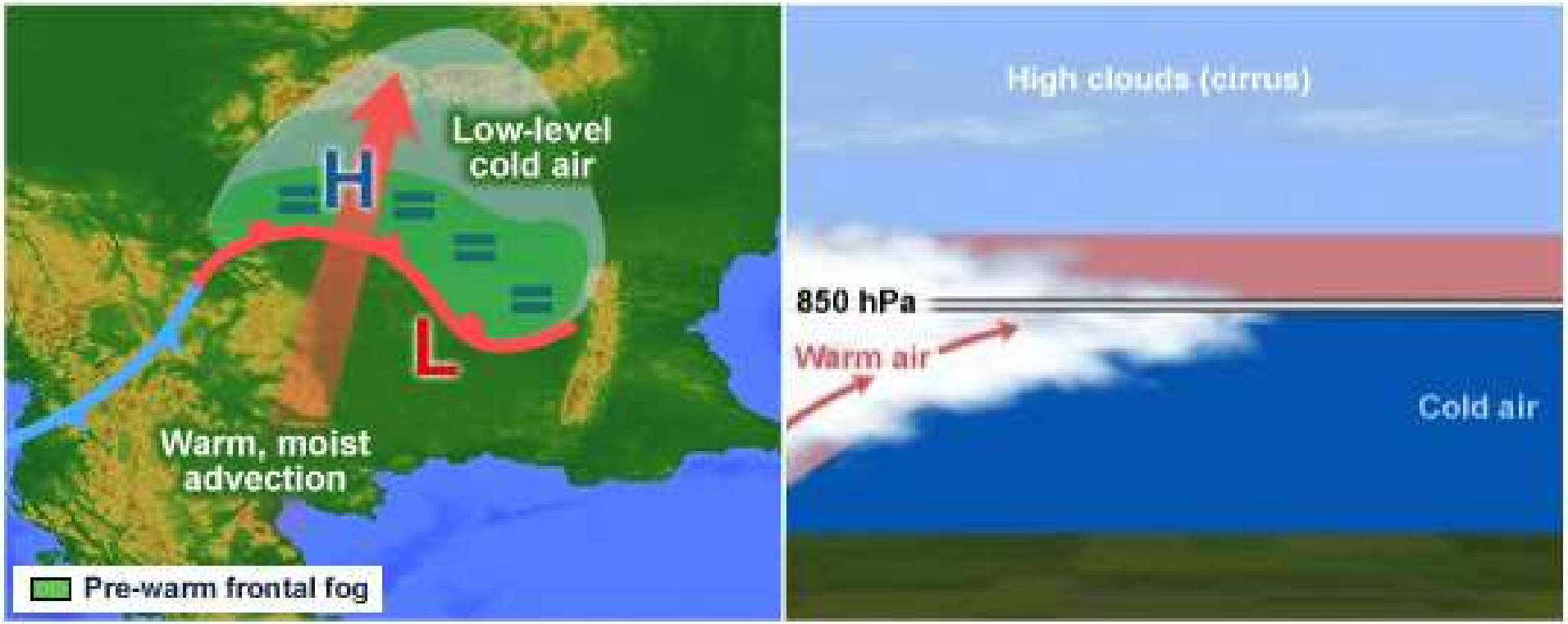


Fogs Formed by Evaporation

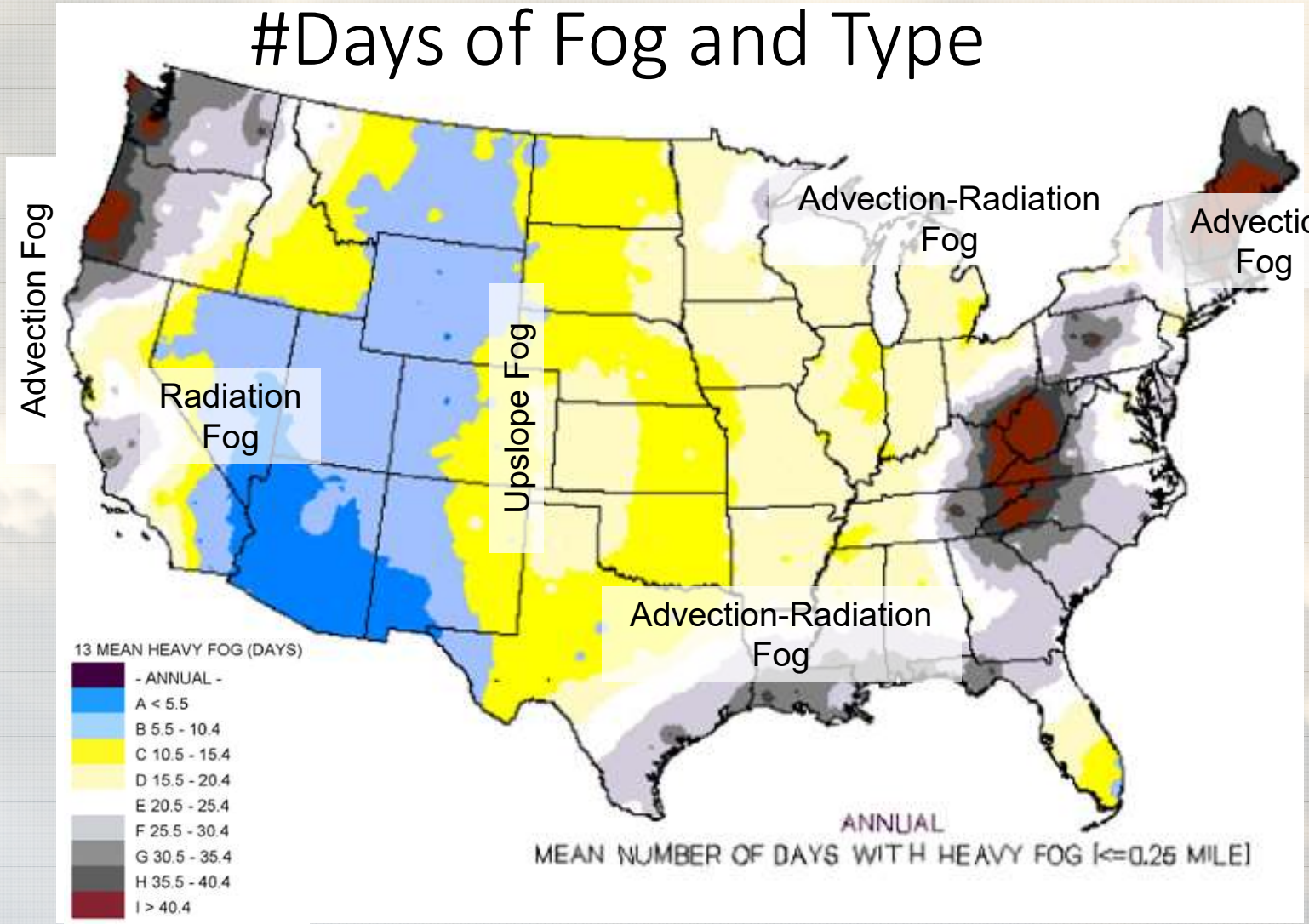
- **Frontal Fog**
  - After warm air is pushed upward
  - If cold air is near dew-point rain can evaporate and then produce fog
  - Results from the addition of water vapor into a cool layer of air



Pre-Warm Frontal Events



#Days of Fog and Type

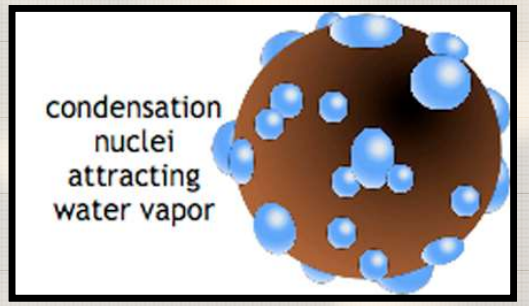


Key Information 1

1. Be able to describe how a **CLOUD FORMS** and what the **THREE** important components.

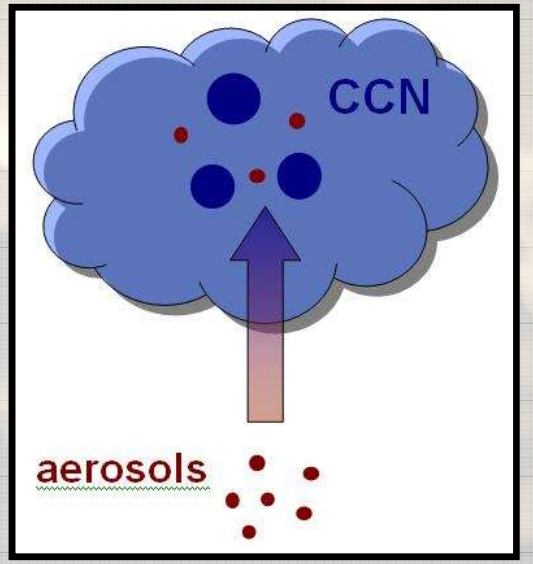
1. Cloud Condensation Nuclei (CCN)

- Serve as the surface for water vapor to condense upon



2. Rising Air

- By one of the methods described last week.
- Causes adiabatic cooling
- Condensation occurs at the LCL

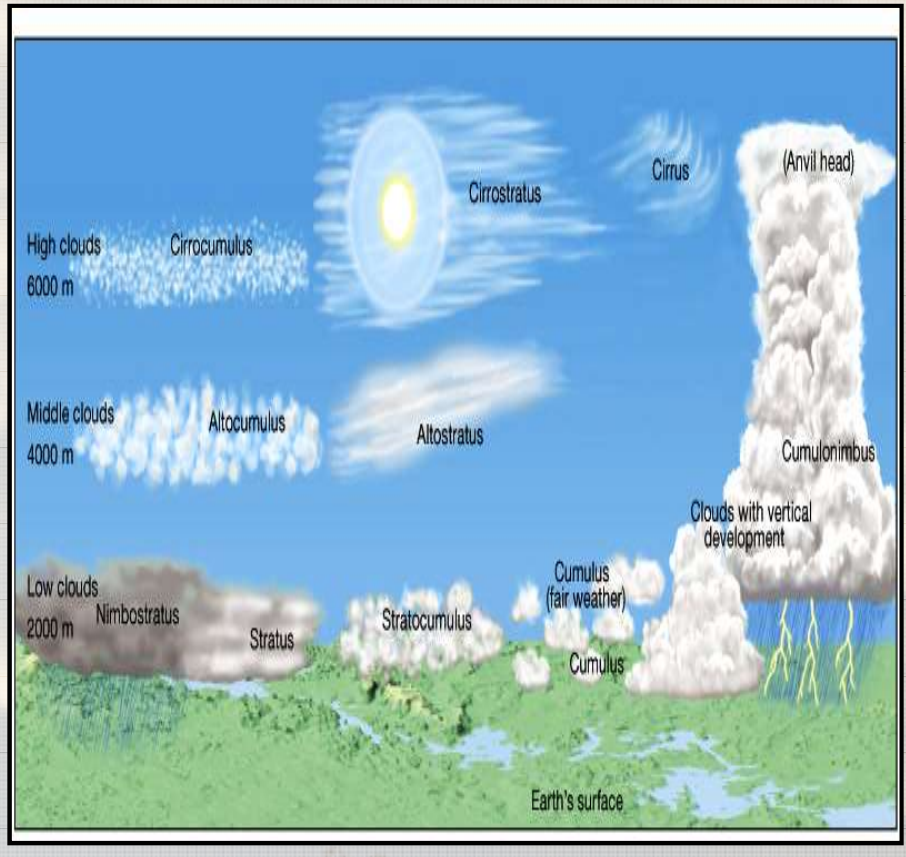


3. Water Vapor

Key Information 2

2. Be able to identify the major **CLOUD TYPES**, their **ALTITUDE CLASS**, and if they are **LIQUID** or **ICE**.

Cloud Family & Height	Cloud Type (abbreviation)	Info
High	Cirrus (Ci)	ICE
	Cirrostratus (Cs)	ICE
	Cirrocumulus (Cc)	ICE
Middle	Altocumulus (Ac)	LIQUID
	Altostratus (As)	LIQUID
Low	Stratus (St)	LIQUID
	Stratocumulus (Sc)	LIQUID
	Nimbostratus (Ns)	LIQUID
Vertically Developed	Cumulus (Cu)	LIQUID
	Cumulonimbus (Cb)	LIQUID on Bottom ICE on top



Key Information 3

3. Be able to identify and describe the different types of **FOG**.

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  - Advection Fog
  - Upslope Fog

- **Fogs formed by Evaporation**
  - Steam Fog
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