Cloud Stories

Clouds can tell us many things about our atmospheric environment including:
- Atmospheric stability
- Cloud microphysics, e.g., ice vs liquid
  - Ice can survive a long time outside of a cloud boundary making the cloud edges diffuse.
- Winds at level of the cloud
- Others?
Cloud Formation
Clouds impact the environment in many ways – Radiation balance, water cycle, pollutant processing, earth-atmosphere charge balance, etc… And they can be beautiful.

Sources of Water Vapor
• The subtropical Ocean
• Lakes and Rivers
• Evapotranspiration from plants.
• Sublimation from snow and ice.

Sources of Water Vapor
The subtropical Ocean is the largest source of water vapor.
Impact of Surface Tension

Surface Tension makes it hard for water molecules to enter droplets, just as this pin is having trouble.

Mechanisms for Cooling the Air

1. Lifting – most clouds form when air is lifted.
   a) Convergence – low press center – stratus
   b) Mountains – lifting by terrain
   c) Fronts – lifting over denser air.
   d) Warm air relative to surroundings
      i) Fires, volcanoes – cumulus
      ii) Latent heat

2. Mixing – seeing your breath on cold day

3. Contact – with cold surface – advection fog

4. Radiation – ground fog

Saturation Vapor Pressure vs Temp.

- The saturation vapor pressure of water increases rapidly with temperature.
- If you cool an air parcel, eventually you will reach saturation.
- The saturation vapor pressure is lower over ice than over water.

Cooling increases Relative Humidity

The saturation vapor pressure of water increases with temperature. Therefore, if the amount of water in the air stays the same, but the temperature increases, then the relative humidity drops.
Cloud classification

Clouds are categorized by their height, appearance and vertical development
- High Clouds - generally above 16,000 ft at middle latitudes (≥6 km)
  - Main types - Cirrus, Cirrostratus, Cirrocumulus
- Middle Clouds – 7,000-23,000 feet (2-6 km)
  - Main types – Altostratus, Altocumulus
- Low Clouds - below 7,000 ft (<2 km)
  - Main types – Stratus, stratocumulus, nimbostratus
- Vertically developed clouds (via convection)
  - Main types – Cumulus, Cumulonimbus

High Clouds
- High clouds
  - White in day; red/orange/yellow at sunrise and sunset
  - Made of ice crystals
- Cirrus
  - Thin and wispy
  - Move SW to NE
  - Indicate fair weather
- Cirrostratus
  - Thin and sheetlike
  - Sun and moon clearly visible through them
  - Halo common
  - Often precede precipitation
- Cirrocumulus
  - Less common than cirrus
  - Small, rounded white puffs individually or in long rows (fish scales; mackerel sky)

Cirrus
- Thin and wispy
- Move SW to NE
- Indicate fair weather
Contrail

Middle Clouds

- Altostratus
  - Gray, blue-gray
  - Often covers entire sky
  - Sun or moon may show through dimly
    - Usually no shadows
- Altocumulus
  - <1 km thick
  - Mostly water drops
  - Gray, puffy
  - Differences from cirrocumulus
    - Larger puffs
    - More dark/light contrast
Altostratus

Altocumulus

Alto Cumulus

Alto Cumulus Undulatus
Low Clouds

- **Stratus**
  - Uniform, gray
  - Resembles fog that does not reach the ground
  - Usually no precipitation, but light mist/drizzle possible

- **Stratocumulus**
  - Low lumpy clouds
  - Breaks (usually) between cloud elements
  - Lower base and larger elements than altostratus

- **Nimbostratus**
  - Dark gray
  - Continuous light to moderate rain or snow
  - Evaporating rain below can form stratus fractus

[Images of Low Clouds]
Nimbostratus

Stratocumulus from below

fractus

Fractus
Stratiform cloud layers

• Stratocumulus
  – Puffy “cotton”
  – Flat base, rounded top
  – More space between cloud elements than stratocumulus

• Cumulus
  – Puffy “cotton”
  – Flat base, rounded top
  – More space between cloud elements than stratocumulus

• Cumulonimbus
  – Thunderstorm cloud
  – Very tall, often reaching tropopause
  – Individual or grouped
  – Large energy release from water vapor condensation
What conditions support taller cumulus development?

- A less stable atmospheric (steeper lapse rate) profile permits greater vertical motion.
- Lots of low-level moisture permits latent heating to warm parcel, accelerating it upward.
- To forecast changing weather you have to predict how the environmental lapse rate will change in time.
Cumulus Castelanus

Cumulonimbus

Cumulonimbus

Cumulonimbus
Orographic Clouds

- Forced lifting along a topographic barrier causes air parcel expansion and cooling
- Clouds & precipitation often develop on the upwind side of the mountains
- Air dries further during descent on the downwind side

Lenticular clouds

- Stable air flowing over a mountain range often forms a series of waves
  - Think of water waves formed downstream of a submerged boulder
- Air cools during the rising portion of the wave and warms during descent
- Clouds form near the peaks of the waves
- A large swirling eddy forms beneath the lee wave cloud
  - Observed in the formation of rotor clouds
  - Very dangerous for aircraft

Mountain Wave or Lenticular Clouds
Mountain Wave or Lenticular Cloud

Mountain Wave or Lenticular Cloud

Mountain Wave or Lenticular Cloud

Mountain Wave or Lenticular Cloud
Summary of Cloud Types

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