The Formation of Dew & Frost
- Dew forms on objects near the ground surface when they cool below the dew point temperature.
  - More likely on clear nights due to increased radiative cooling
- White frost forms when temperature cools below the dew point and the dew point is below 0°C
  - Direct deposition grows slow frost, forming delicate complex crystal hoarfrost.
  - Frost on inside of windows?
- Total yearly dew rainfall equivalent in middle latitudes: 0.5 – 2 inches.

Condensation Nuclei
- Particles suspended in the air, around which water condenses or freezes.
  - Sources: Dust, volcanoes, fires, etc.
  - Sulfates from phytoplankton provide majority of condensation nuclei near oceans.
- Cloud condensation nuclei > 0.1 µm

Hydrophobic
- "Water-repelling"
- Oils, gasoline, paraffin
- Resist condensation, even above 100% RH

Hygroscopic
- "Water-seeking"
- Salts
- Soggy potato chips
Haze
- Dry condensation nuclei (above dew point) reflect and scatter sunlight creating blueish haze.
- Wet condensation nuclei (75% relative humidity) reflect and scatter sunlight creating grayish or white haze.

Fog
- When saturation is reached condensation forms a cloud near the ground.
  - Fog visibility: < 1 km
  - Can be much thicker when formed in dirty city air.
- Tends to fall toward earth when liquid drops are large.
  - 25 µm particles fall 5 cm/s
- Two ways to form:
  - Air cools below dew point
  - Water evaporates and mixes into dryer air

Fog
- Radiation fog: ground cools through conduction and radiation; ground fog
  - Forms best on clear nights, more common in winter when nights are long.
  - Promoted by light breezes which brings more moist air in contact with cold ground.
  - Valley fog created by cold air drainage
- Sunlight usually “burns off” the radiation fog.
  - High inversion fog: the fog layer lifts above the warm ground without dissipating.

Fog
- Advection Fog: warm moist air moves horizontally (advects) over a cool surface.
  - Summer fog on the Pacific coast
  - Keeps the CA redwoods alive
- Advection-Radiation Fog
  - Moist air flows over cold ground
Fog

- **Upslope Fog**: moist air flows up a mountain slope
  - West side of the Rockies
- **Evaporation Fog**:
  - Warm moist surface provides enough moisture to saturate a dry air parcel; short lived
    - Steam fog
    - Heated swimming pools
    - Caribou fog
    - Breath in winter

Foggy Weather

- In general fog is not common for most locations in the US. However several areas do exist with a high frequency of fog. Two causes:
  - Elevation
  - Ocean currents
- Environmental issue: Fog dispersal
  - Mix air with air craft or fans
  - Introduce large particle into air to reduce total number of cloud droplets.
  - Use dry ice to lower temperature below freezing.
Clouds

- Classification of clouds: use Latin words to describe height and appearance.
  - Lamarck, early 1800s
- Factors described
  - Height: low, mid, high, vertical
  - Appearance: shape, density, color

### TABLE 5.2 The Four Major Cloud Groups and Their Types

<table>
<thead>
<tr>
<th>1. High clouds</th>
<th>3. Low clouds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cirrus (Ci)</td>
<td>Stratus (St)</td>
</tr>
<tr>
<td>Cirrostratus (Cs)</td>
<td>Stratocumulus (Sc)</td>
</tr>
<tr>
<td>Cirrostratus (Cc)</td>
<td>Nimbostratus (Ns)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2. Middle clouds</th>
<th>4. Clouds with vertical development</th>
</tr>
</thead>
<tbody>
<tr>
<td>Altocumulus (Ac)</td>
<td>Cumulonimbus (Cb)</td>
</tr>
</tbody>
</table>

**Helpful Latin**
- **Stratus** = Layer
- **Cumulus** = Heap
- **Cirrus** = Curl of hair
- **Nimbus** = Violent rain

### Cirrus Clouds
- Thin and wispy
- Long streamers are called "mares' tails"
- Usually point to fair, pleasant weather.

### High Clouds
- **Ci**: Cirrus
- **Cc**: Cirrostratus
- **Ac**: Altocumulus
- **Ns**: Nimbostratus

### Low Clouds
- **St**: Stratus
- **Sc**: Stratocumulus
- **Cu**: Cumulus
- **Cb**: Cumulonimbus
- **Ns**: Nimbostratus
- **Cirrocumulus**
  - High cotton puffs
  - Rippling appearance distinguishes from cirrus and cirrostratus
  - A “mackerel sky” (scales)

- **Cirrostratus**
  - Thin sheet of ice crystals
  - Often forms halos
  - Often precedes advancing storms

- **Altocumulus**
  - Gray, puffy masses
  - Waves or bands
  - One part of cloud is darker than another, distinguishing from cirrostratus

- **Altostratus**
  - Dimly visible “watery” sun.
  - Gray color and lower than cirrostratus, also no halos and the sun doesn’t cast a shadow.
  - If rain reaches the ground, it’s a nimbostratus.

- **Nimbostratus**
  - Dark gray, wet-looking layer that produces light continuous rain.
  - Darker and lower than altostratus.

- **Stratocumulus**
  - Low lump clouds in rows or patches.
  - Blue sky often visible between clouds.
  - Sometimes crepuscular rays (bands of light) shine through the clouds.
  - Hold up your hand: altocumulus are the size of your thumbnail, stratocumulus are the size of your fist.
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**Stratus**
- Lower layer, can cover entire sky.
- Looks like fog, but doesn’t touch the ground.
- Fog that "lifts" becomes a stratus cloud.
- Common over coastal waters.
- Lower and darker than altocumulus.
- Not a rain cloud like nimbostratus.

**Cumulus**
- Familiar-looking cotton puffs.
- Cumulus humilis = fair weather cumulus
- Cumulus fractus = smaller, ragged-edged
- Cumulus congestus = grown-up, look like cauliflower heads, can grow into cumulonimbus

**Low Clouds**

**Cumulonimbus**
- Giant thunderstorm cloud
- Anvil top.
- Chaotic vertical winds: rain, lightning, hail.
- Top becomes fibrous rather than sharp like cumulus congestus.

**Some Unusual Clouds**
- Not all clouds can be placed into the ten basic cloud forms.
- Unique atmospheric processes and environmental conditions create dramatic and exotic clouds.
- Unusual clouds and weather balloons often cause UFO reports.
Lenticular Clouds

Fig. 5-26, p. 130

Fig. 5-27, p. 130

Fig. 5-28, p. 130

Fig. 5-30, p. 131

Fig. 5-31, p. 131
Contrails
- Contrail = portmanteau of condensation and trail
- Water vapor and exhaust particles act as nucleation sites for condensation

Cloud Observations
- Sky conditions: cloud coverage divided into eighths and each amount associated with term such as scattered clouds.
- Observations: cloud ceilings
  - Ceilometer used at airports to determine height from clouds by light or laser striking clouds and then amount and speed of reflected light recorded.

<table>
<thead>
<tr>
<th>SKY CONDITIONS</th>
<th>DESCRIPTION</th>
<th>CLOUD COVERAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clear (CL) or (BKN)</td>
<td>No clouds</td>
<td>0%</td>
</tr>
<tr>
<td>Few (FEW)</td>
<td>1/8 to 2/8</td>
<td>12.5%</td>
</tr>
<tr>
<td>Scattered (SCT)</td>
<td>2/8 to 3/8</td>
<td>25%</td>
</tr>
<tr>
<td>Broken (BKN)</td>
<td>4/8 to 7/8</td>
<td>50%</td>
</tr>
<tr>
<td>Overcast (OVC)</td>
<td>8/8</td>
<td>100%</td>
</tr>
</tbody>
</table>

Cloud Observations
- Satellite Observations
  - Geostationary, polar orbiting
  - Visible light provides a black and white picture of clouds
  - Infrared approximates cloud temperature which infers height
  - Satellites measure many other variables: sea surface temperatures, ozone, upper level features, snow cover, land cover
Homework for Chapter 5

- Chapter 5 Questions for Review, p. 140
  - #3, 6, 9, 10, 12, 13, 16
- Chapter 5 Questions for Thought, p. 141
  - #1, 15

Infrared satellite images:
http://www.goes.noaa.gov/ECIR4.html