Chapter 1 - Composition and Structure of the Atmosphere

Understanding Weather and Climate
Aguado and Burt

Definitions

• Atmosphere - The gases, droplets and particles surrounding the Earth’s surface.
• Meteorology – The science that studies the atmosphere and its processes.
• Climatology – The science that studies long-term atmospheric conditions
• Weather – Short-term atmospheric phenomena/conditions
Thickness of the Atmosphere

- The atmosphere becomes thinner with height
- There is no easy way to establish the atmosphere's upper boundary

- Top of a thunderstorm = ~12 km
- 100 km above sea level - 99.99997% of the atmosphere is below this height
 Thickness of the Atmosphere

Composition of the Atmosphere

- The atmosphere is a mixture of:
  - gases
  - microscopic solid particles
  - water droplets
Atmospheric Gases

- Permanent – Gases that form a constant proportion of the atmospheric mass.
- Variable – Gases whose distribution in the atmosphere varies in both time and space.

Table 1-2

Permanent Gases

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Formula</th>
<th>Percent by Volume</th>
<th>Molecular Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen</td>
<td>N₂</td>
<td>78.08</td>
<td>28.01</td>
</tr>
<tr>
<td>Oxygen</td>
<td>O₂</td>
<td>20.95</td>
<td>32.00</td>
</tr>
<tr>
<td>Argon</td>
<td>Ar</td>
<td>0.93</td>
<td>39.95</td>
</tr>
<tr>
<td>Neon</td>
<td>Ne</td>
<td>0.002</td>
<td>20.18</td>
</tr>
<tr>
<td>Helium</td>
<td>He</td>
<td>0.0005</td>
<td>4.00</td>
</tr>
<tr>
<td>Krypton</td>
<td>Kr</td>
<td>0.0001</td>
<td>83.8</td>
</tr>
<tr>
<td>Xenon</td>
<td>Xe</td>
<td>0.00009</td>
<td>131.3</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>H₂</td>
<td>0.00005</td>
<td>2.02</td>
</tr>
</tbody>
</table>
Variable Gases

### Table 1-3

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Formula</th>
<th>Percent by Volume</th>
<th>Molecular Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Vapor</td>
<td>H₂O</td>
<td>0.25</td>
<td>18.01</td>
</tr>
<tr>
<td>Carbon Dioxide</td>
<td>CO₂</td>
<td>0.036</td>
<td>44.01</td>
</tr>
<tr>
<td>Ozone</td>
<td>O₃</td>
<td>0.01</td>
<td>48.00</td>
</tr>
</tbody>
</table>

Source: US Defense website

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Aerosols

Source: US Defense website

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Vertical Structure of the Atmosphere

- Layers in the atmosphere
  - Density
  - Chemical Composition
  - Electrical Characteristics
  - Temperature

Characterizing with Chemical Composition

- Homosphere - Region within ~80 km of the Earth’s surface where there is chemical homogeneity.
- Heterosphere - Located above the Homosphere where lighter gases become more dominant with height.
Characterizing with Temperature

- Standard Atmosphere
  - Troposphere (lowest)
  - Stratosphere
  - Mesosphere
  - Thermosphere (highest)
Tropopause

Overshooting Top of a Thunderstorm
Characterizing with Electrical Composition

- Ionosphere
  - Layer extends from the upper mesosphere into the thermosphere.
  - It contains large numbers of electrically charged particles called ions.
    - Ions are formed when electrically neutral atoms or molecules lose one or more electrons and become positively charged. (solar energy)
  - Responsible for the aurora borealis (northern lights)
  - Reflects AM radio waves