LAYERS OF THE EARTH’S ATMOSPHERE
### Dry Air Expressed in Volumes

<table>
<thead>
<tr>
<th></th>
<th>Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen (N₂)</td>
<td>78.1%</td>
</tr>
<tr>
<td>Oxygen (O₂)</td>
<td>20.9%</td>
</tr>
<tr>
<td>Argon (A)</td>
<td>0.9%</td>
</tr>
<tr>
<td>Carbon dioxide (CO₂)</td>
<td>0.035%</td>
</tr>
<tr>
<td>Others</td>
<td>0.065%</td>
</tr>
</tbody>
</table>

Others: Neon (Ne), Helium (He), Krypton (Kr), Hydrogen (H₂), Xenon (Xe), Ozone (O₃), Radon (Rn)
Layers of the Earth’s Atmosphere
From top to Bottom

- Thermosphere
- Mesopause
- Mesosphere
- Stratopause
- Stratosphere
- Tropopause
- Troposphere
**TROPOSPHERE**

- Lowest and thinnest layer
  - 12 km at equator, 8 km at poles
- 90% of the atmosphere’s mass
- **Temperature decreases** with altitude
  - 6°C per kilometer
  - Top of troposphere averages
  - –50°C
- Where weather occurs
- Boundary between the troposphere, and the **stratosphere** is called the **tropopause**
Troposphere

• bottom layer \(\rightarrow\) from Earth’s surface to about 12 kilometers altitude (0 to 7.5 miles)

• where we live & weather happens, clouds form, air moves a lot here \(\rightarrow\) it’s turbulent and well-mixed

• gets colder with increasing altitude... to about \(-55^\circ C\) (-67\(^\circ\) F) at the top (tropopause)

Think about how it gets colder on a mountain.
Troposphere

- Most of atmosphere’s mass is here → the densest layer because gravitational pull is stronger here
- Jet stream is in upper troposphere & lower stratosphere...
- Airplanes do not fly higher than about 11 km...~7 miles up
STRATOSPHERE

- Extends from 10 km to 50 km above the ground
- Less dense (less water vapor)
- **Temperature increases** with altitude
- Almost no weather occurrence
- Contains high level of ozone
  > **ozone layer**
- Upper boundary is called **stratopause**
Stratosphere

- above the troposphere
- You can see where it begins because large cumulonimbus storm clouds reach into and stop at the lower stratosphere
- Extends to ~50 km (31 mi)
- Way less air pressure here...less mass above, less density and less gravitational force
- Strato = layer or “spreading out”...air does not move a lot here
Stratosphere

- **OZONE** is formed in this layer. \( O_3 \) absorbs most UV radiation from the sun.
- Temperatures increase with altitude in the stratosphere because of ozone.

As ozone molecules absorb UV, they get energized, move faster, and produce heat.
**MESOSPHERE**

- Extends to almost 80 km high
- Gases are less dense.
- **Temperature decreases** as altitude increases.
- Gases in this layer absorb very little UV radiation.
Mesosphere

- \(\sim 50-90 \text{ km (31 - 50 mi)}\)
- *meso* = middle
- 99.9\% of mass lies below the mesosphere
- Not enough oxygen to breathe but \% is still the same (What \% is that?)
- Most meteoroids burn up here.... the air is very thin, but still dense enough to slow down meteoroids due because of friction
**Mesosphere**

- There is not an ozone layer to cause heating so, temperatures decrease with altitude in the mesosphere
- **Coldest layer!** down to $-148^\circ F (-100^\circ C)$ at the mesopause...

What is a “pause”?
THERMOSPHERE

- above the mesosphere and extends to almost 600 km high
- temperature **increases** with altitude
- readily absorbs solar radiation
- Temperature can go as high as 1,500 °C
- reflects radio waves
Thermosphere

- **Above the mesospherette to ~690 km (430 miles)....with no real upper limit → space!**

- **least dense of all layers .... few molecules are far apart & moving fast because of radiation absorption**
Thermosphere

- temps can reach $2,000^\circ C$ ($3,600^\circ F$) ... but would feel very cold...too few hot molecules to transfer heat
- Temperatures can vary greatly here because of solar activity
- Thermo = heat
- Sometimes divided into two layers: ionosphere and exosphere
Ionosphere

• lower part of thermosphere

• solar radiation very strong here & is absorbed by the few oxygen & nitrogen molecules resulting in electrically charged gas particles (ions) that cause heat

• **AM radio waves bounce off these ions and back to earth**

• **Aurora Borealis** (**Northern Lights**) ....glowing ions
Exosphere

- Outer thermosphere & outermost layer of the atmosphere
- \textit{Exo} = “outer” (To infinity & beyond!)
- Satellites orbit here
- Atoms & molecules escape into space here
- TV & cell phone signals travel to satellites here and are bounced back
EXOSPHERE

- the interface between Earth and space
- atoms and molecules can escape to space
Air Pressure and Height

- Air pressure always decreases with increasing height. As we move up in the atmosphere there is less mass above us, so the pressure is less, too.

Temperature and Height

Temperature changes in our atmosphere are more complicated and depend on the energy received by air molecules from radiation. The two main sources of radiation are the sun and earth. Temperature decreases in the troposphere, increases in the stratosphere, decreases in the mesosphere, and increases in the thermosphere.
Ozone Depletion

- main cause is CFC pollution
- radiation from the sun causes the CFCs to break down
- releases one chlorine atom
- Chlorine atom reacts with ozone ($O_3$) molecules forming chlorine oxide (ClO) and oxygen gas ($O_2$).
Global Warming

- An increase in Earth’s average surface temperature caused by an increase in greenhouse gases.

- caused by Greenhouse Effect
Greenhouse Effect

- the trapping of heat by gases in the atmosphere

**Greenhouse gases**

- carbon dioxide
- sulfur dioxide
- ozone
- CFCs
- water vapor
Effects of Greenhouse Gas Pollution

- Global warming
  - ice in polar caps will begin to melt
  - water in the ocean expands
  - flooding in lowlands and coastal areas
  - changes in weather patterns