3.1: Atmospheric Composition, Temperature and Function

The atmosphere or our 'air' is a mixture of gases around the Earth which are held by the gravitational attraction of the planet. The gasses in the atmosphere bounce around to fill up the space that we call 'air'. So 'air' is not really nothingness, as we often think of it -- rather it is a critical part of our four earth systems.

Recall from your chemistry classes that a gas is one of the four states of matter (the others being solid, liquid and plasma). Gases are molecules such as O$_2$, N$_2$ and H$_2$O that bounce around, filling up the space that humans call the ‘air’. The air is actually a mixture of gasses (more on that later) which are held around the earth by its gravitational field. The air is most dense (more molecules per area) at sea level, and it is much less dense at high altitudes (have you ever been up in the mountains and found yourself out of breath doing a simple activity? This is because you are breathing in fewer oxygen molecules in each breath). It is difficult to estimate the extent of the atmosphere, as it gradually merges with space. Estimates of 10,000 to 20,000 km are given (compare to the radius of Earth ~ 6400 km); however, most of atmosphere is concentrated in the lower 20-30 km (97-98% by mass - within 30 km of sea level).

The composition of our atmosphere accounts for much of the difference between Earth and other planets. Other planets (except for Mercury) have an atmosphere, but the gasses that make up their atmosphere, in combination with their distance from the sun (too close and therefore too hot, or too far away and therefore too cold) keep life as we know it from thriving. Atmosphere is essential for life on Earth as it supplies oxygen, water, CO$_2$ and some nutrients (N) to living organisms, and protects living organisms from temperature extremes and excessive UV radiation.

Up to about 80 km, the composition of atmosphere is highly uniform; therefore, the term homosphere is applied. The lower atmosphere is composed of two groups of gasses:
I. Gases which have minimal effect on weather and climate. Concentration of these gases is constant everywhere throughout the homosphere. By volume:

- 78% - nitrogen (N\textsubscript{2}); chemically inactive, neutral
- 21% - oxygen (O\textsubscript{2}); very active chemically, reacts readily with other substances in the process of oxidation: slow (rock decay) or fast (fuel combustion)
- 0.93% - argon (Ar); inert
- < 0.04% - trace gases: Neon (Ne), Helium (He), Methane (CH\textsubscript{4}), Krypton (Kr), Hydrogen (H\textsubscript{2})
- Ozone (O\textsubscript{3}) - extremely important as a shield for life - absorbs UV rays

II. Gases which are significant for weather and climate. Concentration of these gases (especially water vapor) can vary considerably from one place to another.

- 0-4% - water vapor (< 1% on average) - absorbs long wave radiation, emits counter radiation (greenhouse effect), transfers heat by latent heat transfer (see below)
- 0.033-0.036% - carbon dioxide (CO\textsubscript{2}) - together with water vapor is responsible for greenhouse effect

The atmosphere is also composed of water, ice and dust particles (aerosols). Aerosols are found most frequently near their sources, for example, cities, sea coasts or active volcanoes. However, particles can be carried a great distance. For example, a significant study is now being undertaken by the US Geological Survey in Texas, studying microbes carried on atmospheric dust particles blown over from Africa!

Atmospheric particles can have a significant impact on weather and climate. Some particles are hydrosopic (they absorb water), and therefore stimulate water condensation and formation of clouds. Some particles absorb or reflect solar radiation and decrease the amount of energy that reaches the surface. This can be a very good thing, as much of the insolation that intersects the earth is very short wave (high energy) and can be very harmful to life (x-rays, gamma rays and ultra violet radiation).

The vertical pattern of temperature consists of a series of layers in which temperature alternately increases and decreases with a relatively thin transitional zone in between. Based on the temperature characteristics, atmosphere can be divided into 5 layers (-spheres) and 3 transitional zones (-pauses).

---

Troposphere

From Greek tropos - "turn" - lowest atmospheric layer, zone of intense vertical mixing and turbulence. This is where most weather and climate phenomena take place. The depth of troposphere depends on the

- latitude (deepest at the equator, shallowest at the poles);
- season (deepest in summer, thinnest in winter);
- changes with the passage of warm and cold air masses.
Stratosphere

From Latin *stratum* - "a cover" - layered, stratified zone of atmosphere without much vertical mixing.

- 18 - 48 km above the surface
- Contains ozone layer.
- Heat in the stratopause comes from UV absorption by ozone.
- *Mesosphere* (*meso* - "middle") - layer in between stratopause and thermosphere
- 50 - 80 km

Thermosphere


Exosphere

Outer layer, which in turn, gradually thins out into interplanetary space.

The atmosphere is composed of two more important layers:

Ionosphere

Layer of electrically charged molecules and atoms, ions in the top half of mesosphere and lower thermosphere. Aids in long-distance communication by reflecting radio waves back to Earth.

Ozone sphere (Ozone layer)

Zone of maximum concentration of ozone (O₃, three atom form of oxygen) - practically coincides with stratosphere (recall that ozone is the source of heat for the upper stratosphere; heat is generated through reaction with UV radiation). Absorbs UV, serves as a shield for living organisms. It's important to realize that ozone constitutes only a tiny fraction of atmosphere - < 0.002% by volume.

For deeper understanding, search for information on the temperature profile of the atmosphere.

Contributors and Attributions

- K. Allison Lenkeit-Meezan (Foothill College)