

# METEOROLOGY

The atmosphere, the Sun, radiation, cloud formations, air masses & fronts, global weather patterns & forces, severe weather, optical phenomena, and more

## THE ATMOSPHERE

### Gas Composition

- The atmosphere is composed mainly of nitrogen, an odorless, colorless gas
- Oxygen is the next most abundant element, with other gases represented only in trace amounts
- The atmosphere is a fluid; it has no set shape and moves easily when acted upon by external forces

### Description of Composition

- There are two ways to describe the composition of the atmosphere:
  - By the weight of the constituents
  - By their volume

Principal Gases in Dry Air	
Constituent	Percent by Volume
Nitrogen	78.084
Oxygen	20.946
Argon	.934
Carbon dioxide	.034
Ozone	.000004
Water vapor	~4.0*

\*Water vapor is a variable gas, whereas the others are more permanent

### Possible Originations

- The Earth has what is known as a **secondary atmosphere**, or an atmosphere created after the formation of the planet
- The large gas planets (Jupiter, Saturn, Uranus, and Neptune) are entirely made of gas; Jupiter has a **primary atmosphere**, or an atmosphere that originated with the formation of the planet
- There are two hypotheses for the formation of the Earth's atmosphere:
  - Outgassing:**
    - When the Earth formed, it was a giant spinning ball of molten lava
    - As it cooled, gases trapped in the lava were "belched" up by large volcanoes
    - The combination of these outgassed vapors and the biological transformation of the chemistry of the atmosphere by hundreds of millions of years of plant growth gave us our contemporary atmosphere
  - This hypothesis is more widely accepted

### Comet Impacts:

- A comet is a giant clump of frozen water and gases
- If many large comets struck the Earth several billion years ago, they could have left a residue of water, carbon dioxide, oxygen, and other gases that eventually collected into the atmosphere

### Levels of the Atmosphere



- Because the density of the atmosphere decreases exponentially with altitude, 99% of the atmosphere is within the first 20 miles of the Earth's surface

### Troposphere

- The lowest level of the atmosphere
- Named in 1908 by Léon Teisserenc de Bort, it means "the region where air turns over"
- The layer in which most of the clouds and weather phenomena occur
- Has two layers:
  - The layer that touches the Earth is called the **boundary layer** and is about 5-10 miles high at the equator
  - The troposphere's upper limit is called the **tropopause** and varies in height with both season and location
- In the troposphere, temperatures decrease with altitude; this is called a **lapse rate:**
  - This rate averages out to be  $-6.5^{\circ}\text{C}$  for every kilometer
  - In the tropopause, the temperature does not change with height

- The layer of the atmosphere that exists between 12-31 miles above the Earth's surface
- The temperature in the stratosphere increases with height because the **ozone layer** is located here; when temperatures increase with height, it is called an **inversion:**
  - The ozone layer absorbs ultraviolet radiation from the Sun (see **Heat Transfer & the Greenhouse Effect**, p. 2, and **Ozone**, p. 6)
  - There has been a decrease in the ozone layer due to chlorofluorocarbons (CFCs) and other man-made and natural chemical processes
  - Scientists have found that ice crystals, due to the extremely low temperatures of this region, can also deplete ozone, but research is ongoing in this area

### Mesosphere

- The layer of the atmosphere above the stratosphere
- The temperature in the mesosphere begins to fall, often reaching the **coldest temperatures** of any part of the atmosphere:
  - This cold region extends from 31-56 miles above the Earth's surface, and its temperature can reach  $-100^{\circ}\text{C}$

### Thermosphere

- The layer of the atmosphere above the mesosphere
- It starts about 56 miles above the Earth's surface
- Here, again, the temperature begins to rise with altitude:
  - This is because the atmosphere in this region, while very thin, allows particles to move at extremely high speeds
  - Temperature is the average kinetic energy of the particles; since the particles are moving so fast, the temperature is very high in this layer

### Ionosphere

- The layer within both the thermosphere and mesosphere in which there are enough ionized particles to affect the transmission of radio signals:
  - Radio signals bounce off the ionosphere to extend their range past the horizon
  - This effect is stronger at night when the Sun's radiation does not affect the ionosphere
- Ionized particles are atoms or molecules that have more electrons than protons, making them negatively charged, or more protons than electrons, making them positively charged
- Begins about 37 miles above the Earth's surface and extends upward
- Reflects long-wavelength, low-energy radio signals (like AM radio) back to Earth but allows short-wavelength, high-energy radio signals (like FM radio) to pass through into space

## THE SUN, HEAT, TEMPERATURE & RADIATION

### The Earth's Tilt & the Seasons



- As it orbits around the Sun, the Earth spins on its axis, which is tilted with respect to the Earth-Sun orbital plane, not perpendicular to it:
  - The North Pole does not point directly up and down as the Earth spins but rather is inclined at  $23.5^{\circ}$  with respect to the orbital plane
- As the Earth orbits the Sun, in a near-circular path called an ellipse, it remains at the same angle and pointing in the same direction; this tilt means that during a certain time of the year, the **Northern Hemisphere** is pointed toward the Sun more than the **Southern Hemisphere:**
  - During this period, the Northern Hemisphere receives more direct sunlight than the Southern Hemisphere and therefore becomes warmer; this is summer in the Northern Hemisphere and winter in the Southern Hemisphere; the first day of summer for the Northern Hemisphere is called the **summer solstice**, which has the most day-light hours of the year:
    - On or around June 21, the Sun's most direct perpendicular rays are hitting the Earth at  $23.5^{\circ}$  N latitude, the Tropic of Cancer; this is the farthest north the perpendicular rays will be

# Meteorology Study Guide

**H Kauffman**



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