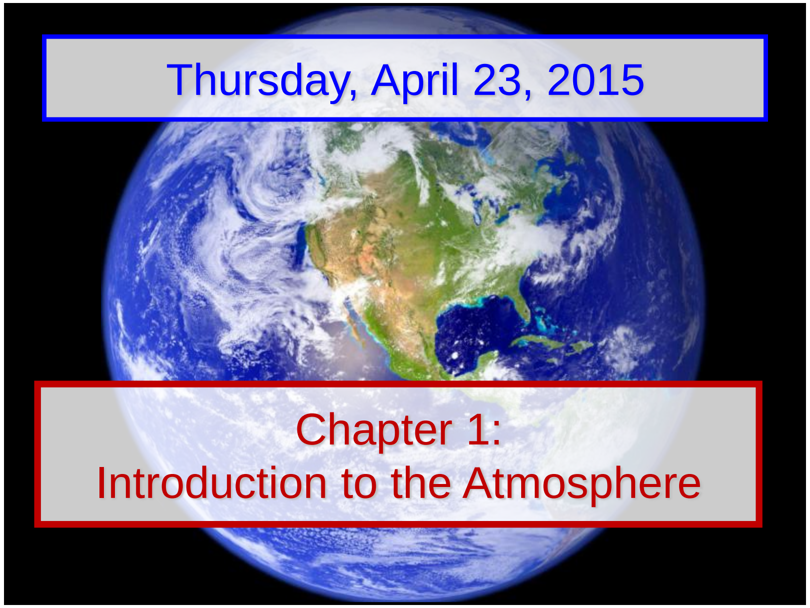


Chapter 1

- Weather and Climate
- The Earth's 4 Spheres
- Earth System Science
- Atmospheric Composition
- Air Pressure
- Atmospheric Structures

Weather

Definition:

The state of the atmosphere at any given time and place.

You can think of Weather as a snap shot of atmospheric conditions.

Climate

Definition:

A description of the long-term Patterns of Weather for a certain place and time.

Often called the *Average Weather* for a place, this definition is inaccurate because it misuses the statistical term "average"

Hazards from the Atmosphere: *Our Wild World*

The atmosphere is capable of producing a very wide range of weather conditions that are all well within it's ***normal*** expected range.

These conditions can be in any duration, from very short (a 10-minute thunderstorm) to very long (a 10-year drought)

Hazards from the Atmosphere: *Severe Weather*

- **Tornadoes**
- **Hurricanes**
- **Floods**
- **Droughts**
- **Fires**
- **Heat Waves**
- **Snow Storms**
- **Ice Storms**
- **Avalanche**
- **Hail**
- **Thunderstorms**
- **Lightning**

4 Spheres of the Earth

- Lithosphere (Geosphere)
- Hydrosphere
- Atmosphere
- Biosphere

Lithosphere

The solid inorganic portion of the Earth (composed of rocks, minerals and elements)

It can be regarded as the outer surface and upper crust portions of the solid Earth.

On the surface of the Earth, the lithosphere is composed of three main types of rocks

- Igneous - rocks formed by solidification of molten magma.
- Sedimentary - rocks formed by the alteration and compression of old rock debris or organic sediments.
- Metamorphic - rocks formed by alteration of existing rocks by intense heat or pressure.

Hydrosphere

The waters of the Earth

Water exists on the Earth in various places (stores) and in various forms.

Stores including the atmosphere, oceans, lakes, rivers, soils, glaciers, and groundwater.

Water moves from one store to another by way of: evaporation, condensation, runoff, precipitation, infiltration and groundwater flow.

Forms include ice, liquid and water vapor.

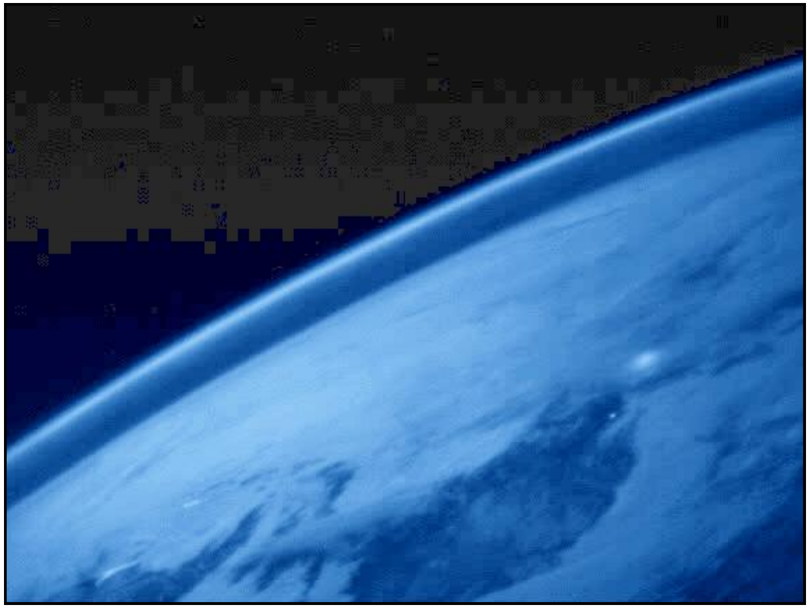
Atmosphere

The vast gaseous envelope of air
that surrounds the Earth

Its boundaries are not easily defined.

The atmosphere contains a complex system
of gases and suspended particles that behave
in many ways like fluids.

Many of its constituents are derived from
the Earth by way of chemical and
biochemical reactions.



Biosphere

The Biosphere consists of all living things, plant and animal

This zone is characterized by life in profusion, diversity, and ingenious complexity.

Cycling of matter in this sphere involves not only metabolic reactions in organisms (living), but also many abiotic (non-living) chemical reactions.

Interconnections

None of the spheres exist in exclusion.

Some amount of each (solid, liquid, gas and life) exists within each of the 4 spheres

This interconnected nature of these spheres is called Earth System Science

Earth Systems Science

The understanding of Earth a a complete entity.

An interacting set of physical, chemical and biological systems, that together product a “Whole Earth.”

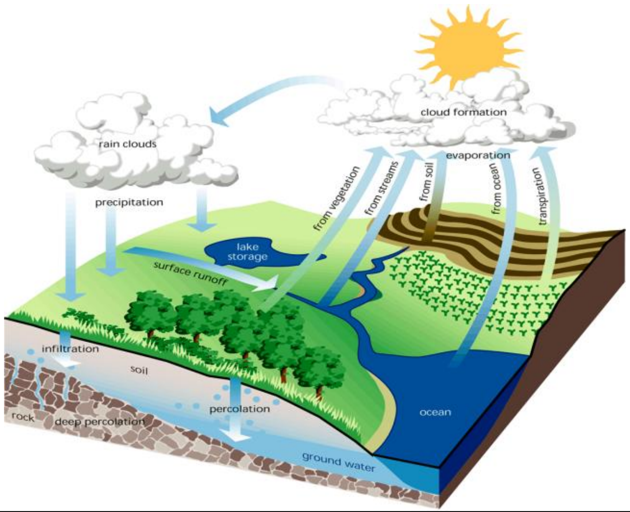
The science that studies
the relationships and patterns
among natural systems, geographic areas,
society, cultural activities and
the interdependence of these all across space.

Systems in Science

- **Closed System**
  or
- **Open System**

- **Negative Feedback**
  or
- **Positive Feedback**

The Hydrologic Cycle



The Atmosphere

The atmosphere has changed substantially at least 4 different times on Earth.

1. **At first there was really very little atmosphere** except for the gaseous contents of the planetesimals. As the Earth slowly compressed into a more solidified planet, its gravitational pull attracted much of the material remaining from the formation of the solar system. Many of these contained frozen gasses and other elements (such as water).

2. The Earth begins to compress under the tremendous force of its own gravity. These forces generated heat which begins to both melt the frozen gasses and the rock itself. The Earth's core becomes liquid rock. **Offgassing releases gasses trapped in that original rock**. These gasses are released during violet eruptions which covered much of the planets surface.

The Atmosphere

The atmosphere has changed substantially at least 4 different times on Earth.

3. With the **emergence of plants**, the atmosphere changed yet again. Plants take in CO_2 (carbon dioxide) and **release O_2** (oxygen). This was a slow process that took millions of years, but eventually the plants produced enough oxygen that other life forms evolved to take advantage of all this free oxygen.

4. The fourth atmosphere is where we are today where the **atmospheric system has somewhat equalized** between the needs of plants and animals (flora and fauna). You might say this system has a certain balance to it.

The Atmosphere

The atmosphere has changed substantially at least 4 different times on Earth...
is it changing yet again?

Mankind is pumping gasses into the atmosphere at an ever increasing rate. We are not totally sure what effect all these chemicals will have on the way the atmosphere works. Some of the interactions are well understood (CFC's and their effect on stratospheric ozone or certain chemicals that react in the atmosphere to produce acid rain) while others are unknowns.

Stay tuned!
Things might just get interesting out there!

Air: *What is it?*

Air: ***A simple mixture of naturally odor-less, color-less, taste-less and form-less gas, which is so thoroughly blended that it acts as if it where a single gas.***

The air that we breath is just one part of a complex atmosphere. The air as we know it resides in the lowest portion of the atmosphere, the part all life lives in, called the troposphere.

Air is a combination of mostly 3 gasses, with many more trace gasses. Even though the "big 3" are more than 99% of the total atmosphere, the trace gasses (at less than 1%) can still have a very important impact on how the atmosphere works.

Air Composition

Gas	Symbol	Percent
Nitrogen	N_2	**78.08%**
Oxygen	O_2	**20.94%**
Argon	Ar	**0.93%**
	Subtotal	**99.95%**
Carbon Dioxide	CO_2	**0.038%**
Plus lesser amounts of Neon, Methane, Helium, Krypton, Hydrogen, Xenon, etc.		
Other Important Components: Water Vapor (H_2O), Dust Particles and Ozone (O_3)		

Air Pressure

Air pressure is the measure of how many air molecules are present in a given quantity of air.

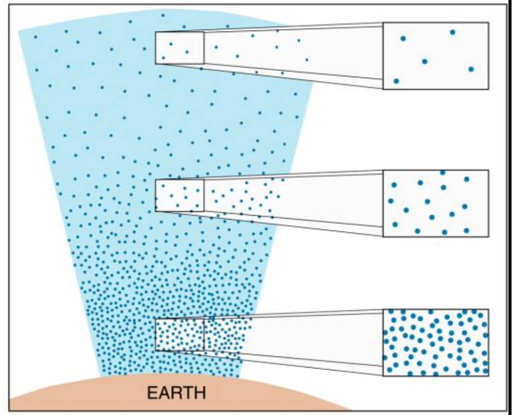
Air pressure is mostly determined by **gravity**. Air has mass. It is a very small amount of mass, but it is still there. Therefore, gravity is pulling air molecules close to the Earth's surface.

Air pressure is **highest at the surface** and it gets **lower as we move up** (away from the surface). This might seem a little counter-intuitive, but it makes sense when you think of air as something having mass.

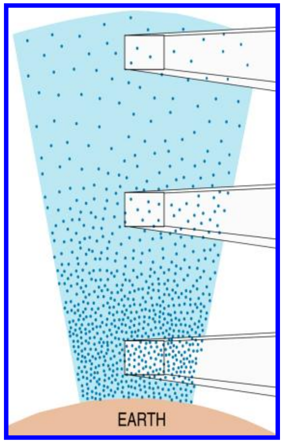
Our atmosphere is considered to begin at the surface of the Earth and extend out to ~300 miles (480km). However, there are still elements of the atmosphere as far out as 20,000 miles!

Air Pressure

Because the Earth's gravity is pulling these air molecules toward the surface, we have the majority of the atmospheric gasses concentrated near the surface.



Air Pressure



Percent	Miles	Meters
100%	300 miles	480,000m
99%	31 miles	50,000m
90%	10 miles	16,000m
75%	7 miles	10,700m
50%	4 miles	5,500m

Air Pressure

At high altitudes, the amount of air molecules in a certain quantity of air will be much less than at the surface.

Animals (people included) have needed to adapt to living under such conditions. According to the United Nations, in 1990, more than 140 million people were living above 8,000 ft.

Air Composition – Minor Comp's

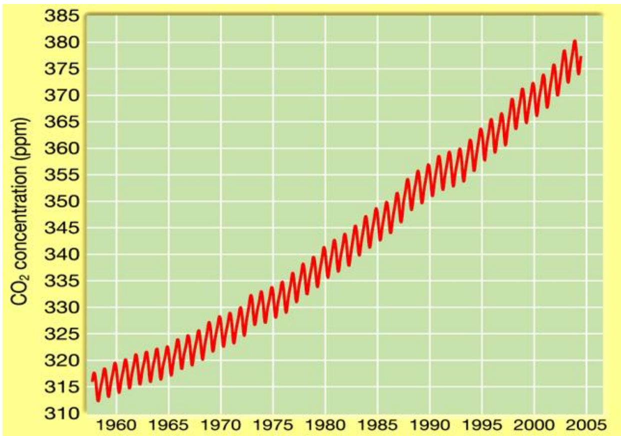
Gas	Symbol	Percent
Nitrogen	N_2	78.08%
Oxygen	O_2	20.94%
Argon	Ar	0.93%
	Subtotal	99.95%
Carbon Dioxide	CO_2	0.038%
Everything else combined = 0.012% Plus lesser amounts of Neon, Methane, Helium, Krypton, Hydrogen, Xenon, etc.		
Other Important Components: Water Vapor (H_2O), Dust Particles and Ozone (O_3)		

Carbon Dioxide CO_2

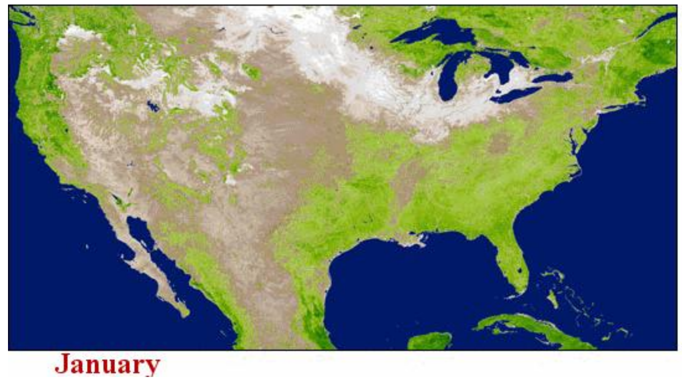
Is a small (<0.038%) but very important component of the atmosphere.
It has a large role as an energy absorber as part of the Greenhouse Effect (which is a major part of global warming).

The percentage of CO_2 in the atmosphere has been rising steadily since the beginning of the 20^{th} century (1900). Readings taken since the 1960s atop Mauna Loa in Hawaii show a remarkable record of CO_2 gas concentrations since that time.

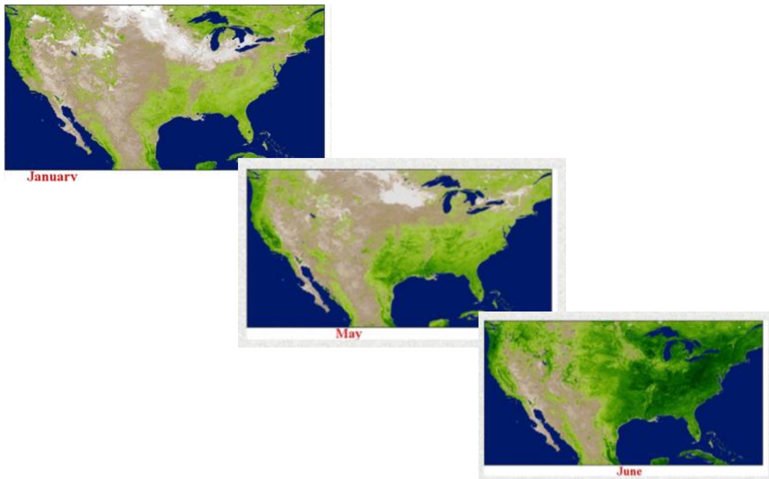
CO_2 Concentrations



CO_2 Concentrations



CO_2 Concentrations



Water Vapor (H_2O gas)

While water vapor varies in atmospheric concentration (0 – 4%), it's the source for all clouds and precipitation. Also it is another greenhouse gas because of its ability to absorb radiated energy

When water vapor changes state from a gas to a liquid (condensation) during cloud formation, it releases latent heat energy which is the main source of energy in storms (e.g. hurricanes)

Water Vapor (H_2O gas)

Aerosols

Tiny solid and liquid particles that are suspended in the atmosphere.

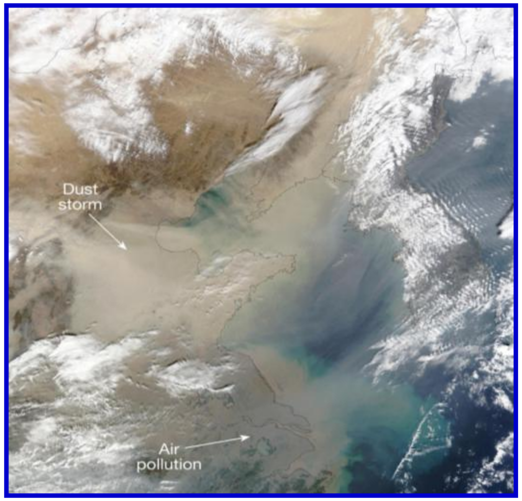
Since they originate at the earth's surface, most are in the lower atmosphere.

Aerosols have two main effects:

- Act as **Condensation Nuclei** (cloud formation)
- Absorb or block incoming solar radiation

Some aerosols: Sea salt, fine soil, smoke, soot, pollen, microorganisms, ash & dust

Aerosols



Ozone in the Stratosphere

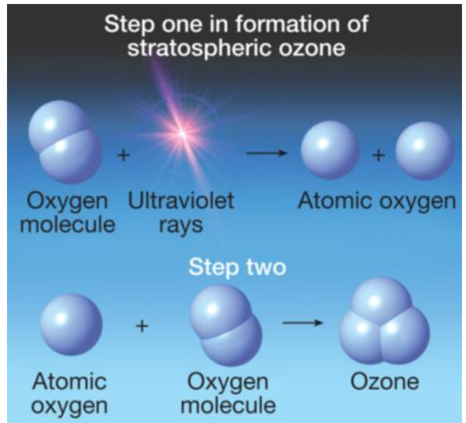
- **Ozone is 3 molecules of Oxygen (O_3)**
- **When these react to incoming UV radiation, the Ozone absorbs the UV radiation, breaking into 2 parts → O + O_2 (heat is also released)**
- **These parts (O and O_2) can easily recombine back into O_3**

Ozone in the Stratosphere

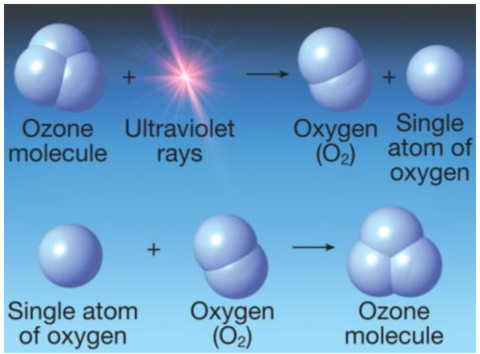
When CFC's are present:

- The CFC's break down into → chlorine (Cl)
- The chlorine breaks the O_3 → ClO + O2
- The ClO gets a free O and splits into → Cl + O_2
- Reduces the O_3 (which blocks UV radiation)
- Thus, we get
  - reduced absorption of UV radiation
  - increase in UV related illness (Skin Cancer)

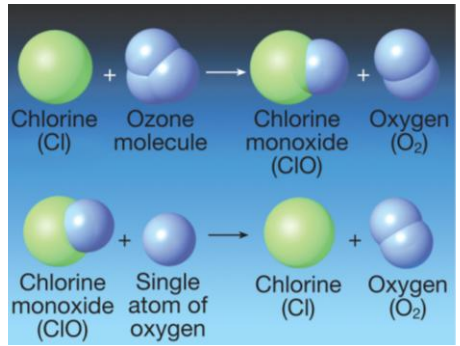
Ozone in the Stratosphere



Ozone in the Stratosphere



Ozone in the Stratosphere



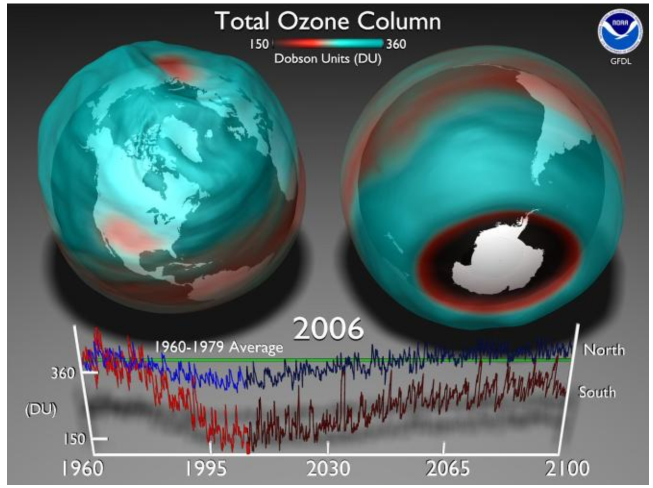
Ozone in the Stratosphere

In 1987 the United Nations, led by the United States, held an international meeting to address head on the growing problem of the loss of stratospheric ozone.

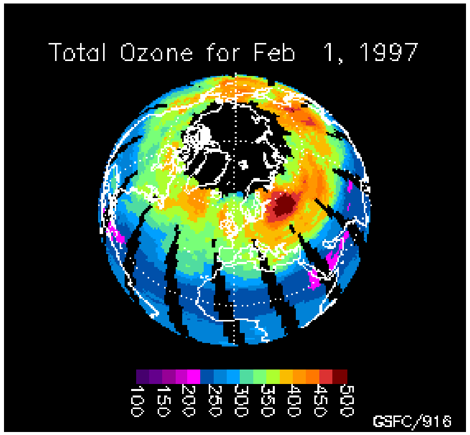
The Montreal Protocol established legally binding controls on the creation and emission of ozone depleting chemicals (chiefly CFC's).

Since this time, CFC production has been curtailed and the ozone hole expansion has begun to wane.

Ozone Hole



Ozone Hole



Link to animation

Structural Profiles

We will explore the atmosphere using three different criteria:

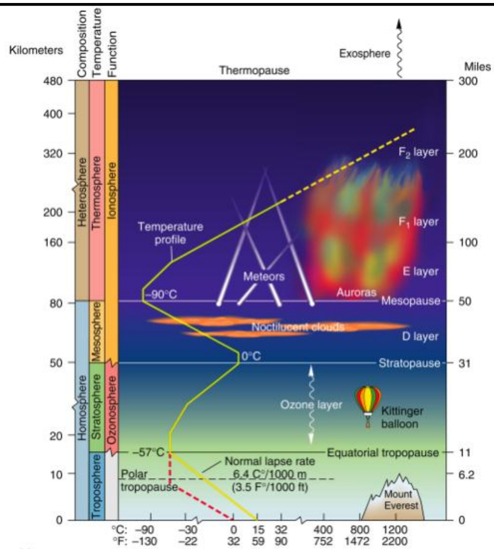
- **Thermal**
- **Composition**
- **Function**

Think of these as three different ways of viewing the same material.
The atmospheric profile does not change, we are simply using three different ways to view the same information.

Profiles

This diagram shows three different methods used to explore the atmosphere:

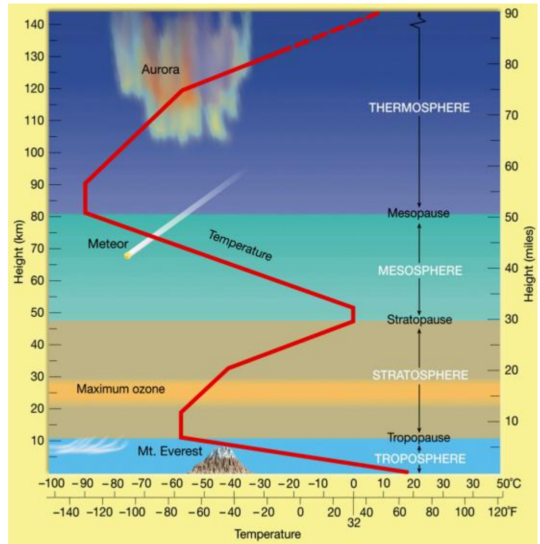
- Composition
- Temperature
- Function



Profiles

This diagram shows the

Thermal profile



Temperature

Atmospheric Temperature is divided into four distinct atmospheric layers…

- Thermosphere
- Mesosphere
- Stratosphere
- Troposphere

These are different from each other based on the way the atmosphere responds to Insolation. This is the way the atmosphere changes temperature (heating or cooling) as we ascend into the atmosphere).

The **THERMO**sphere = **High Heating** (Kinetic, not Sensible)
The **MESO**sphere = the **Middle** area
The **STRATO**sphere = Horizontal layer (**Ozone**)
The **TROPO**sphere = **Lowest Level** (where **Weather** happens)

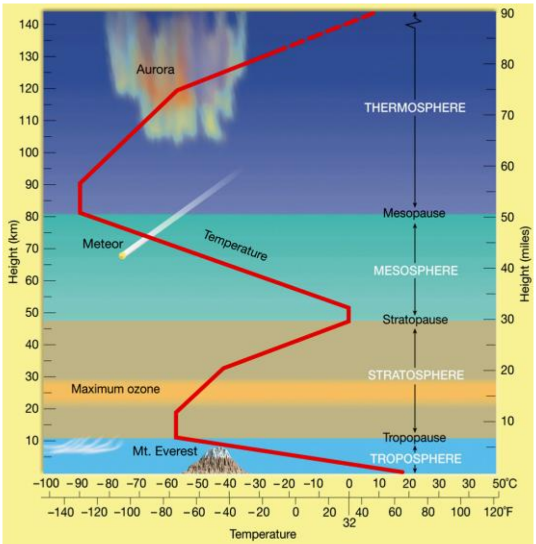
Temperature

"Sphere"	Location	Effect
Thermosphere	*50 - 90 miles*	*Heated by incoming shortwave radiation, but kinetic energy*
Mesosphere	*30 – 50 Miles*	*Similar to the troposphere, it cools by the Normal Lapse Rate*
Stratosphere	*7.5 – 30 Miles*	*Heating by Ozone absorbing UV radiation*
Troposphere	*Surface – 7.5 Miles*	*Air cools as it rises due to pressure changes: the Normal Lapse Rate*

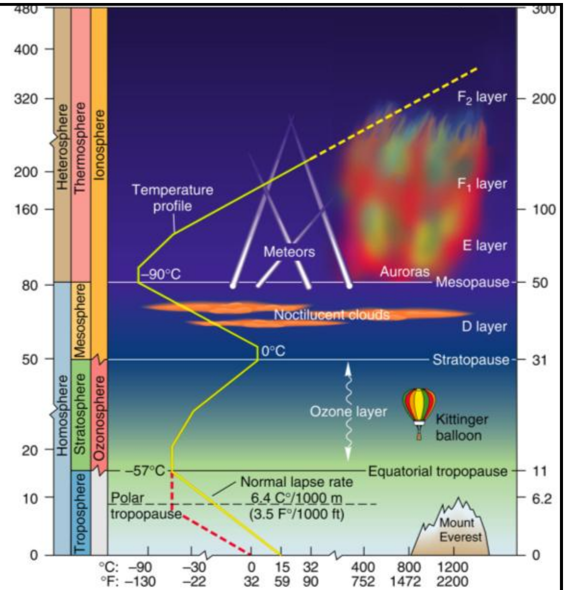
Profiles

This diagram shows the

Thermal profile



Profiles



Composition

Atmospheric Composition is divided into two distinct atmospheric layers…

- **Heterosphere**
- **Homosphere**

These are different from each other based on the composition of the basic elements found in the atmosphere.

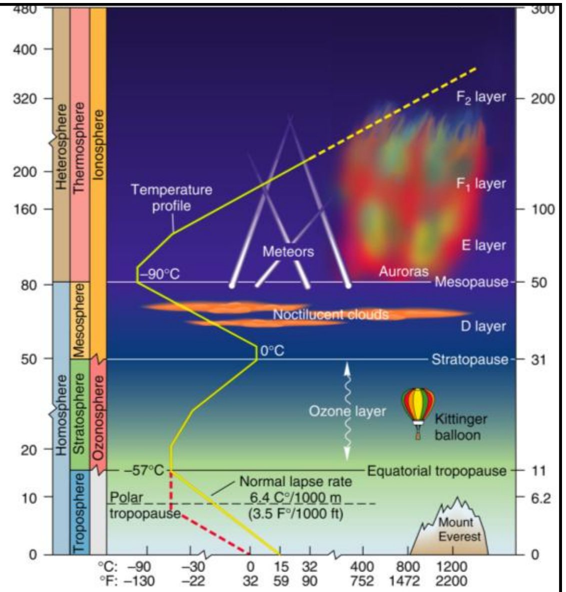
The **HETERO**sphere is where we have **DIFFERENT** elements.

The **HOMO**sphere is where we have **ONE MIX** of elements.

Composition

"Sphere"	***Location***	***Effect***
Heterosphere	***50 miles - Space***	***Layered by atomic weight***
Homosphere	***Surface – 50 Miles***	***Mixed into a single "air" in the lower atmosphere by weather***

Profiles



Function

Atmospheric Fuction is divided into
two distinct atmospheric layers… (well, really three!)

- **Ionosphere**
- **Ozonosphere (Ozone Layer)**

They differ based on the functions
they provide in the atmosphere.

The **IONO**sphere absorbs/deflects **shortwave radiation**

The **OZONO**sphere **absorbs UV** radiation

Function

"Sphere"	Location	Effect
Ionosphere	50 - 250 miles	Absorption and Deflection of Shortwave Radiation
Ozonosphere	7.5 – 30 Miles (Stratosphere)	Absorption of UV by Ozone

Ionosphere & Auroras

This is an electrically charged layer of the atmosphere. Here molecules of nitrogen and oxygen are ionized as they absorb high-energy shortwave solar radiation.

In this process, these molecules lose atoms, which are then free to travel as electrical currents

At certain times (usually during high solar flare events) these electrical currents will interact with both the earth's magnetic field and incoming radiation to produce spectacular aurora events

- **Aurora Borealis (northern lights) → NORTH**
- **Aurora Australis (southern lights) → SOUTH**

Ionosphere & Auroras