Space & Atmospheric Physics

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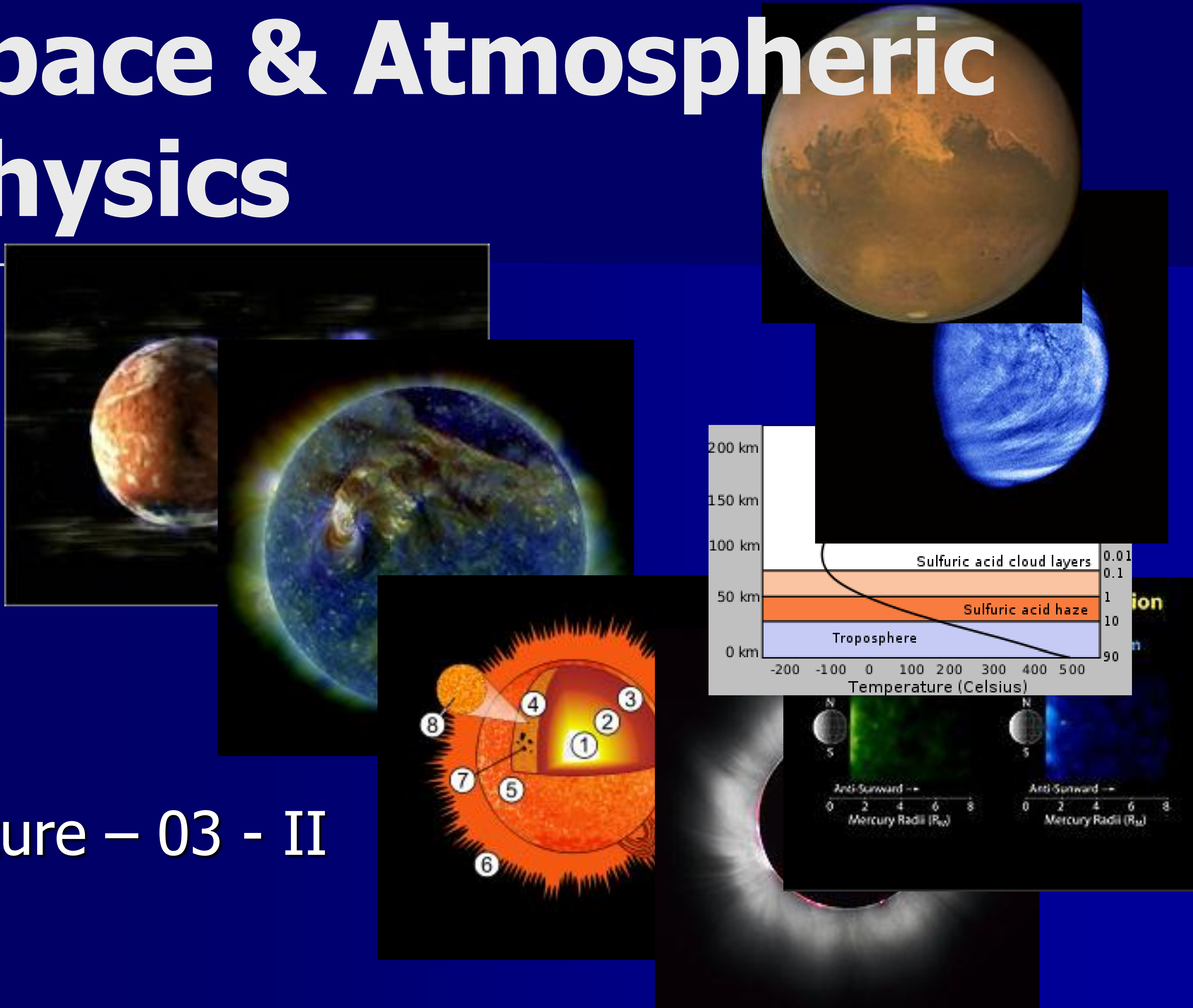


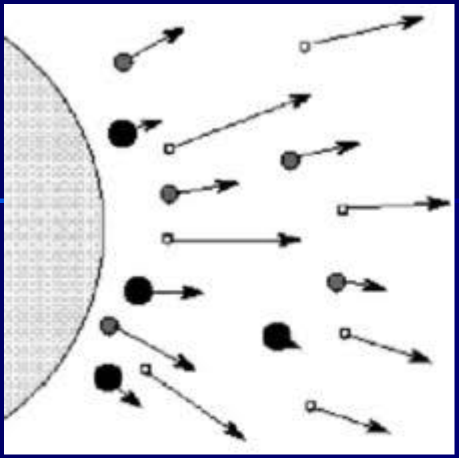
Lecture – 03 - II

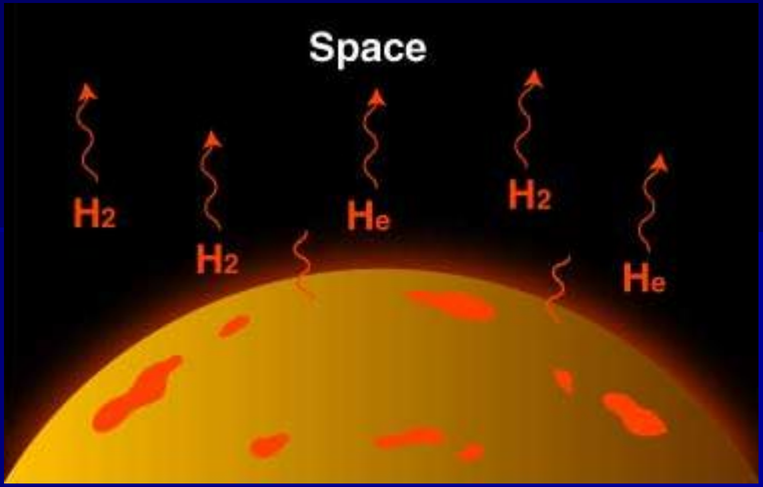
Planetary Atmospheres

Planetary Atmospheres

- Formation and Evolution of Planetary Atmospheres
- The Structure of the Terrestrial Atmosphere
- The Temperature of the Neutral Atmosphere
- **The Escape of the Atmospheric Gases**
- The Atmospheres of the Planets

The Escape of the Atmospheric Gases





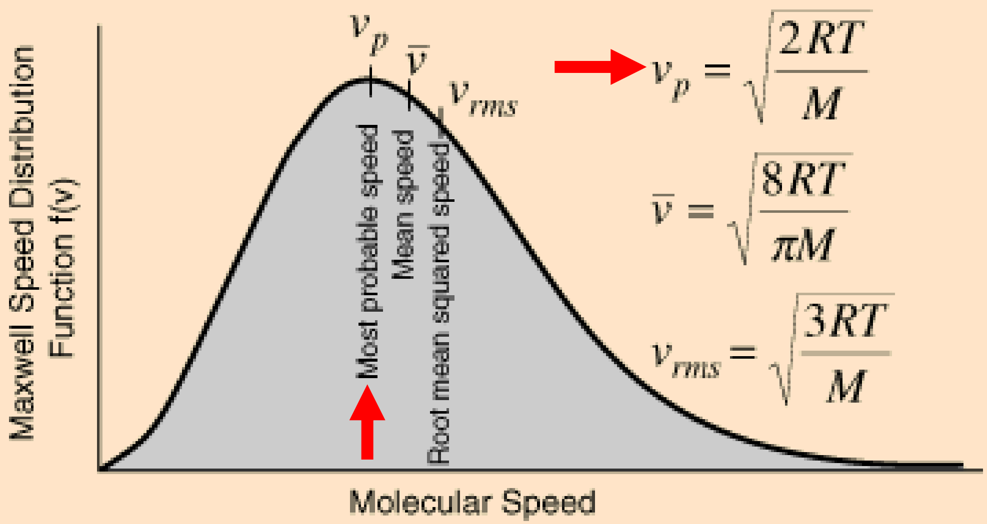
The kinetic theory of gasses shows that the particle velocities of a gas in a thermal equilibrium follow a Maxwellian Distribution, which in polar coordinates is given by the expression,

$$N\ f(V)dV\,d\Omega = 4\pi\,N \cdot \frac{e^{-\left(V/V_m\right)^2}}{\left(\pi V_m^2\right)^{3/2}} V^2 dV\,Sin\theta\,d\theta\,d\phi$$

Molecular Speed Calculation

The speed distribution for the molecules of an ideal gas is given by

$$f(v) = 4\pi\left[\frac{M}{2\pi RT}\right]^{\frac{3}{2}} v^2 \exp\left[\frac{-Mv^2}{2RT}\right]$$



$$v_p = \sqrt{\frac{2RT}{M}}$$

$$\bar{v} = \sqrt{\frac{8RT}{\pi M}}$$

$$v_{rms} = \sqrt{\frac{3RT}{M}}$$

The calculation of molecular speed depends upon the molecular mass and the temperature. For mass

m= 29 amu

M= 0.029 kg/mol

and temperature

T= 300 K

T= 26.850000 C

the three characteristic speeds may be calculated.

The nominal average molecular mass for dry air is 29 amu.

Most probable speed= v_p = 414.75819 m/s = 1493.1295 km/hr = 927.78766 mi/hr

Mean speed= $\bar{v}$ = 468.00451 m/s = 1684.8162 km/hr = 1046.8962 mi/hr

RMS speed= v_{rms} = 507.97297 m/s = 1828.7027 km/hr = 1136.3031 mi/hr

The Escape of the Atmospheric Gases

Maxwellian Distribution

$$f(V) = 4\pi\left(\frac{M}{2\pi RT}\right)^{3/2} V^2 \cdot \exp\left(-MV^2/2RT\right)$$

The most probable speed (Vm)

The **most probable speed** is the speed associated with the highest point in the Maxwell distribution.

$$\frac{df(v)}{dv} = 0$$

$$\frac{d[f(V)]}{dV} = 4\pi\left(\frac{M}{2\pi RT}\right)^{3/2} \frac{d}{dV}\left(V^2 \cdot \exp\left(-MV^2/2RT\right)\right) = 0$$

The Maximum/Minimum value is :

$$V = \left(\frac{2kT}{M}\right)^{1/2}$$

The Escape of the Atmospheric Gases

To find is it Maximum or Minimum : should be checked the second derivative of the **Maxwellian Distribution**

$$\frac{d^2[f(V)]}{dV^2} = 4\pi\left(\frac{M}{2\pi RT}\right)^{3/2} \frac{d}{dV}\left(\frac{d}{dV}\left(V^2 \cdot \exp\left(-MV^2/2RT\right)\right)\right)$$

.

.

.

Then substitute $V = \left(\frac{2kT}{M}\right)^{1/2}$

$$\frac{d^2[f(V)]}{dV^2} = (-)ve$$

Then this V value should be the maximum value of the **Maxwellian Distribution**. This is called "The **most probable speed " ,**

$$V_m = \left(\frac{2kT}{M}\right)^{1/2}$$

Molecular Speed Calculation

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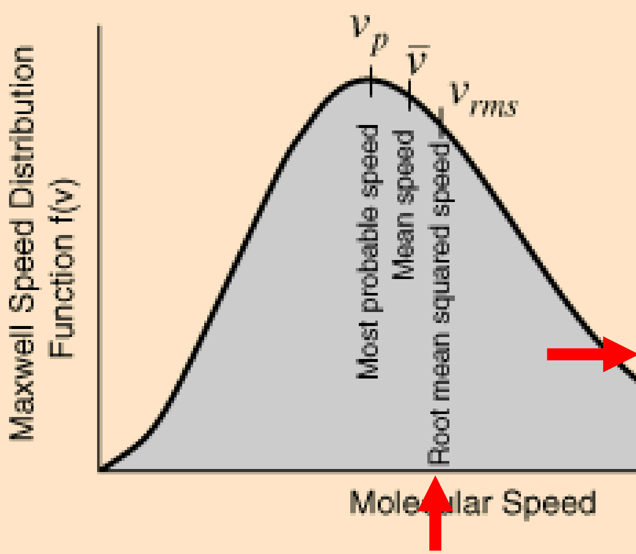

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R.M.S. Molecular Speed :

The Kinetic Energy of a atom in the Earth's atmosphere whose mass is m,

$$= \frac{1}{2} m V_{rms}^2$$

The Kinetic Energy of a atom in the Earth's atmosphere in the temperature T in Kelvin, (in 3D Form)

$$= \frac{3}{2} kT$$

Above two equations should be equal,

$$\frac{1}{2} m V_{rms}^2 = \frac{3}{2} kT$$

$$\therefore \quad V_{rms} = \left(\frac{3kT}{m} \right)^{1/2}$$

$$\therefore \quad V_{rms} = \left(\frac{3RT}{M} \right)^{1/2}$$

When the Kinetic Energy of a particle exceeds the Potential Energy of the Gravitational Field of the Earth, this particle can in principle escape to the interplanetary space. The lowest velocity allowing the particle to escape is called the Escape Velocity V_e.

The Kinetic Energy of a particle in the Earth's atmosphere whose mass is m,

$$= \frac{1}{2} m V_e^2$$

The Potential Energy of a particle on the surface of the Earth, $= -\frac{GMm}{R}$

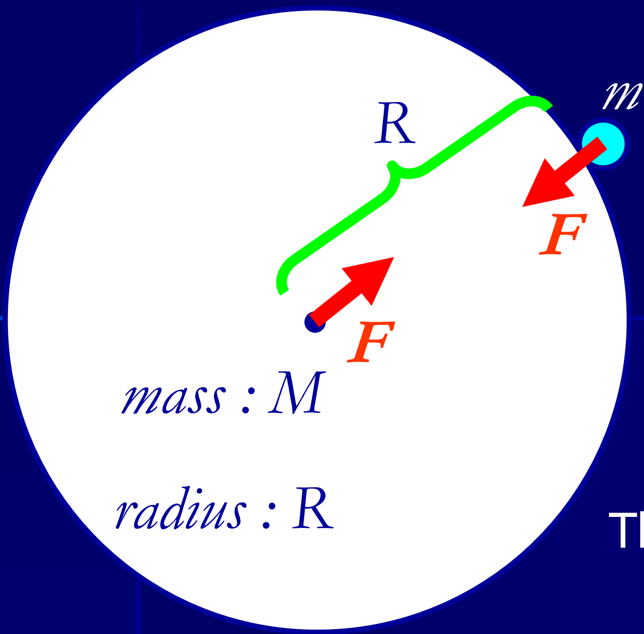
Where, M is the mass of the Earth and R is the Radius of the Earth.

Kinetic Energy exceeds Potential Energy, the particle can escape ;

$$\frac{1}{2} m V_e^2 = \frac{GMm}{R}$$

$$\therefore \quad V_e = \left(\frac{2GM}{R} \right)^{1/2}$$

Where, $GM = gR^2$ Proof : P.T.O



Using the Newton's Gravitational Law :

$$F = G\frac{Mm}{R^2}$$

Using the definition of the Gravitational field intensity :

$$g = \frac{F}{m} \rightarrow F = mg$$

Therefore,

$$G\frac{Mm}{R^2} = mg$$

$$\therefore \quad GM = gR^2$$

Therefore, the Escape Velocity of a planet:

$$V_e = \left(\frac{2GM}{R}\right)^{1/2}$$

$$V_e = \left(\frac{2gR^2}{R}\right)^{1/2}$$

$$V_e = (2gR)^{1/2}$$

- For the Earth

$$g = 10\, ms^{-2}$$

$$R = 6.4 \times 10^6\, m$$

$$v_e = (2gR)^{\frac{1}{2}}$$

$$\therefore \quad v_e = 11{,}200\, ms^{-1}$$

$$\therefore \quad \frac{V_e}{V_m} = \frac{(2gR)^{1/2}}{\left(\frac{2kT}{m}\right)^{1/2}} = \left(\frac{R}{kT/mg}\right)^{1/2} = \left(\frac{R}{H}\right)^{1/2}$$

Where, $H = kT/mg$

The ratio of $V_e : V_m$

$$\frac{V_e}{V_m} = \left(\frac{R}{H}\right)^{1/2}$$

$$\frac{V_e}{V_m} = \left(\frac{6400\,km}{8.7\,km}\right)^{1/2}$$

$$\frac{V_e}{V_m} = 27.6 \approx 28$$

$$V_e \approx 28\, V_m$$

Escape Velocity *Most Probable Velocity*

- For the Earth

$$H = kT/mg$$

$$H = \frac{(1.38\times 10^{-23})(300)}{(4.8\times 10-26)(9.81)}$$

$$H = 8.7\,km$$

As a result, particles in the atmosphere can not escape to the interplanetary space!

(But this is not the only condition necessary for the particles to escape)

Planetary Atmospheres

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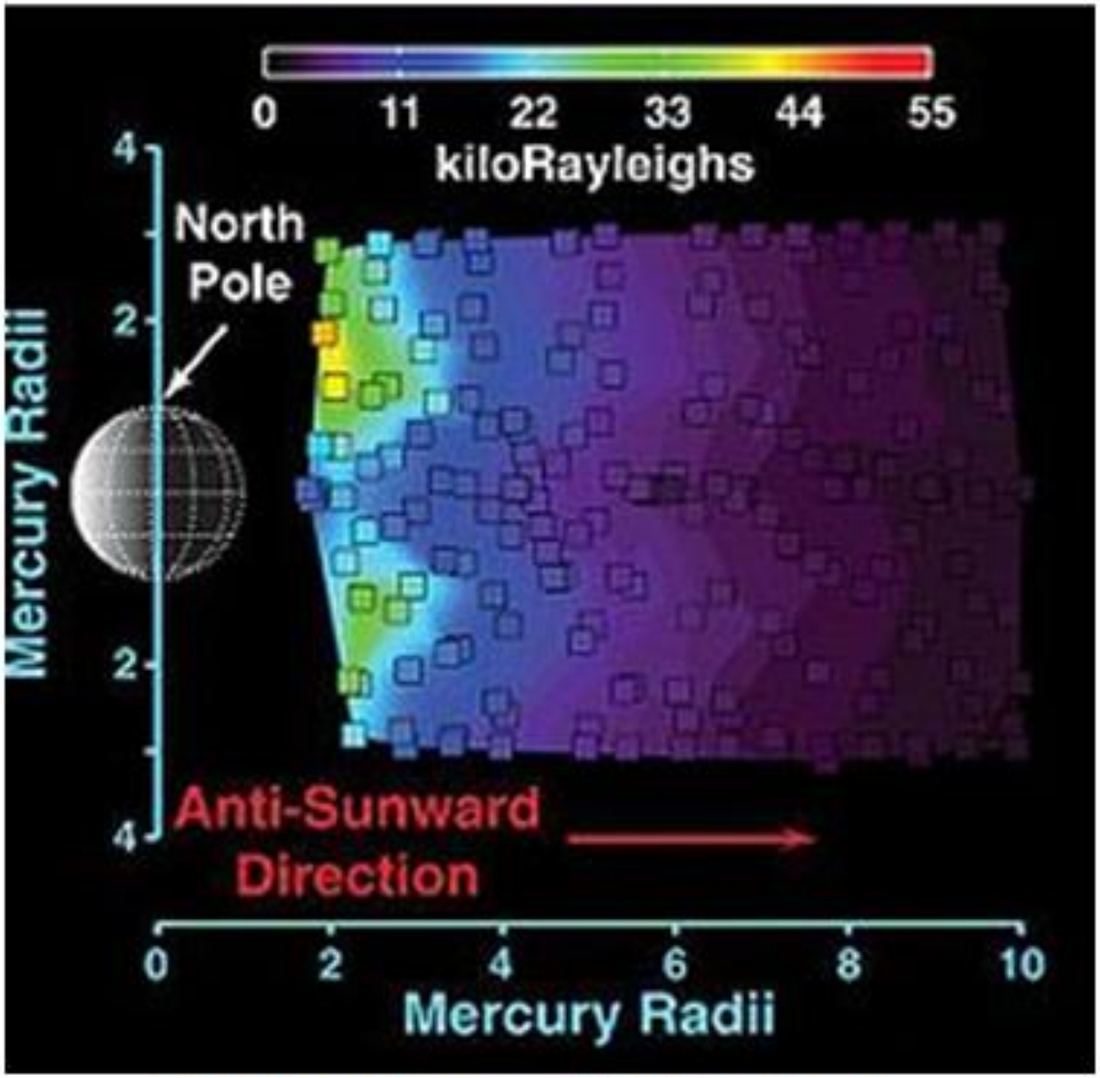
Atmosphere of Mercury

Atmosphere of Mercury



Atmosphere of Mercury

Atmosphere of Mercury

Species	CD,[n 1] cm^{-2}	SD,[n 2] cm^{-3}
Hydrogen (H)	$\sim 3 \times 10^{9}$	~ 250
Molecular hydrogen	$< 3 \times 10^{15}$	$< 1.4 \times 10^{7}$
Helium	$< 3 \times 10^{11}$	$\sim 6 \times 10^{3}$
Atomic oxygen	$< 3 \times 10^{11}$	$\sim 4 \times 10^{4}$
Molecular oxygen	$< 9 \times 10^{14}$	$< 2.5 \times 10^{7}$
Sodium	$\sim 2 \times 10^{11}$	$1.7–3.8 \times 10^{4}$
Potassium	$\sim 2 \times 10^{9}$	~ 400
Calcium	$\sim 1.1 \times 10^{8}$	~ 300
Magnesium	$\sim 4 \times 10^{10}$	$\sim 7.5 \times 10^{3}$
Argon	$\sim 1.3 \times 10^{9}$	$< 6.6 \times 10^{6}$
Water	$< 1 \times 10^{12}$	$< 1.5 \times 10^{7}$
Other	neon, silicon, sulfur, argon, iron, carbon dioxide, etc.	

1. ^ Column density
2. ^ Surface density

Atmosphere of Mercury

History

Mercury is the most difficult planet to observe due to its proximity to the Sun.

The viability of an atmosphere on Mercury had been debated before Mariner 10's 1974 flyby. **On the one hand proximity to the Sun would induce a high temperature.** On the other hand **the dark hemisphere would be very cold, causing many gases to freeze.**

By the 1960s **some evidence had accumulated indicating that Mercury might have a thin atmosphere.**

By 1974 a **consensus had formed that Mercury, like the Moon, had virtually no atmosphere.**

Atmosphere of Mercury

Properties

Mariner 10's UV observations have established an upper bound on the exospheric surface density at about 10^5 particles per cubic centimeter. This corresponds to a surface pressure of less than 10^(−14) bar (1 nPa).

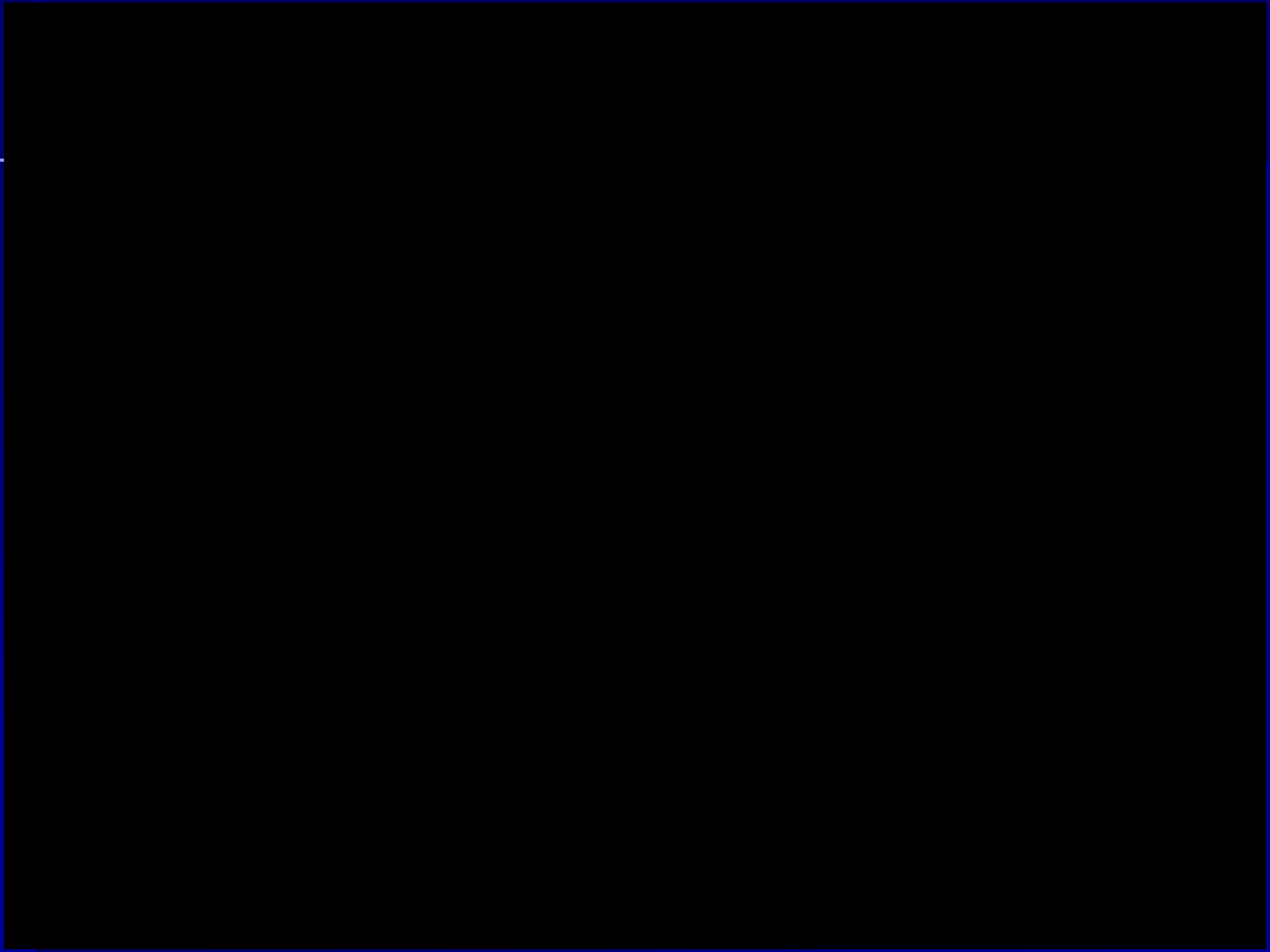
For exospheric atomic hydrogen, the temperature appears to be about 420 K, a value obtained by both Mariner 10 and MESSENGER. The temperature for sodium is much higher, reaching 750–1500 K on the equator and 1,500–3,500 K at the poles. Some observations show that Mercury is surrounded by a hot corona of calcium atoms with temperature between 12,000 and 20,000 K.

Tail

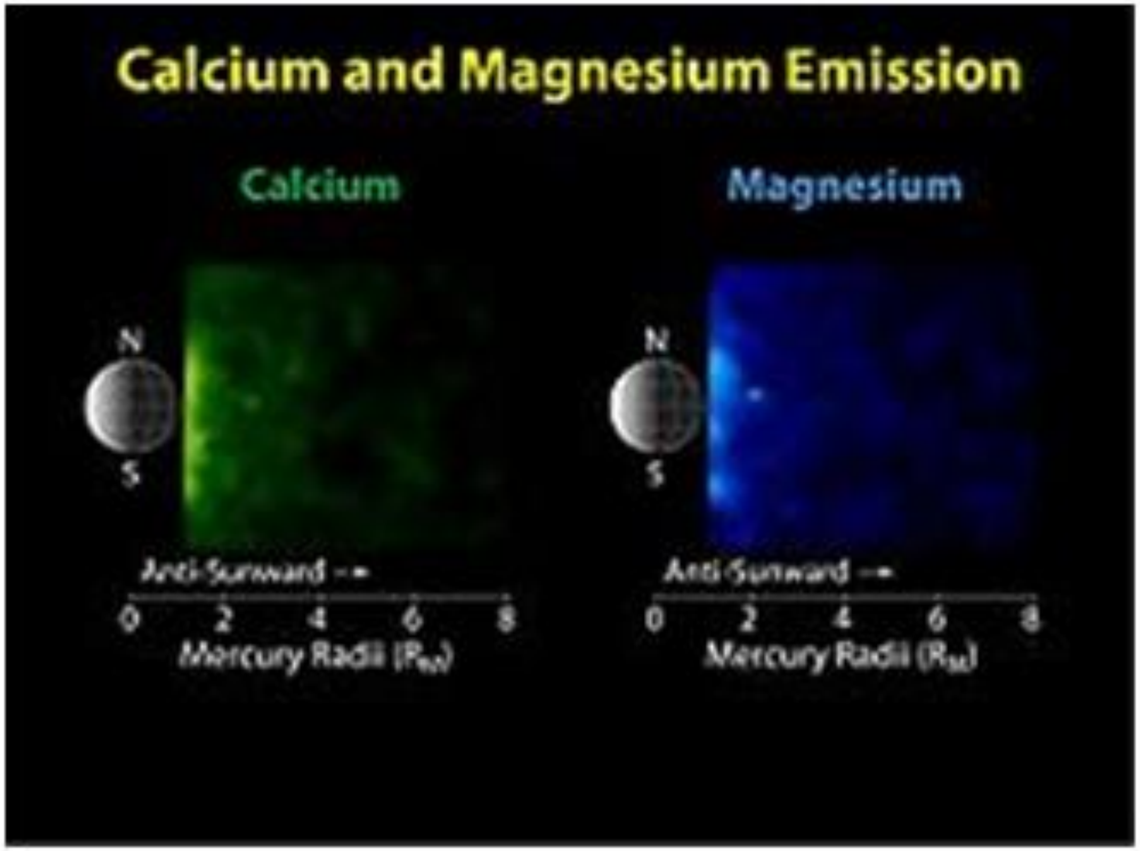
Because of Mercury's proximity to the Sun, the pressure of Solar light is much stronger than at Earth's location. Solar radiation pushes neutral atoms away from the Sun, creating a comet-like tail behind Mercury. The main component in the tail is sodium, which has been detected as far as 56,000 km (about 23 $\mathbf{R}_M$) from the planet. **This sodium tail expands rapidly to a diameter of about 20,000 km at a distance of 17,500 km**.

Atmosphere of Mercury

Mercury's sodium tail



Atmosphere of Mercury



Ca and Mg in the tail

Atmosphere of Mercury

Origin

Mercury's exosphere is constantly escaping into space, implying that some process resupplies its constituents. The main source of hydrogen and helium is likely to be the Solar wind. Other atomic and molecular species are thought to originate from the **Herman** crust through three main processes:

- vaporization of surface material by meteoritic impacts,
- Sputtering by energetic charged particles from the Solar wind; and
- photo- and electron-induced desorption of alkali metal atoms.

Mercury's orbit has a significant eccentricity, which causes a strong variation in the Solar light and particle fluxes reaching the planet. Solar flares contribute additional variation.

Atmosphere of Venus

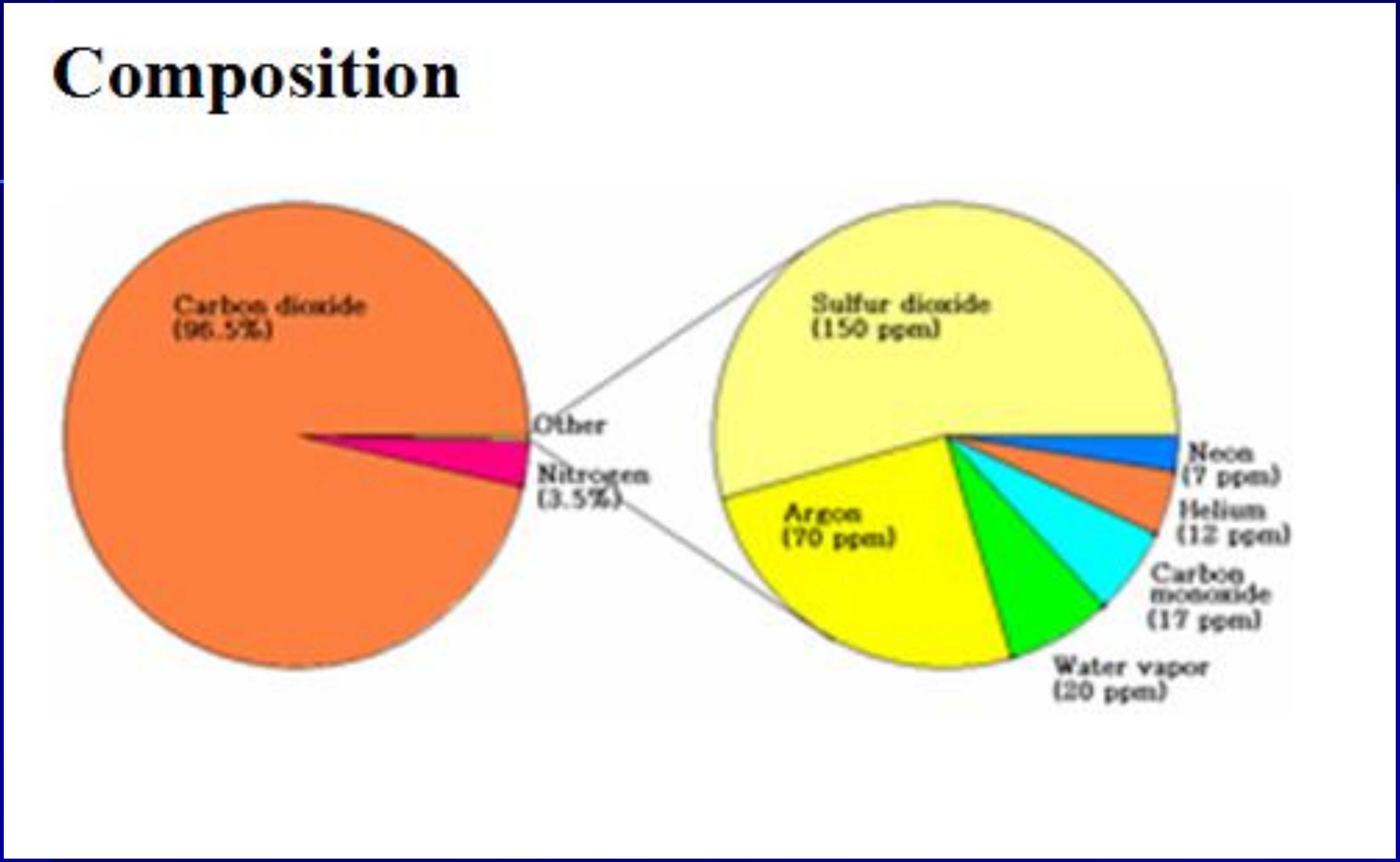
Atmosphere of Venus

Cloud structure in Venus' atmosphere in 1979, revealed by ultraviolet observations from Pioneer Venus Orbiter

Atmosphere of Venus

General information[1]	
Height	250 km
Average surface pressure	(92 bar or) 9.2 MPa
Mass	4.8×10^{20} kg
Composition[1][2]	
Carbon dioxide	96.5 %
Nitrogen	3.5 %
Sulfur dioxide	150 ppm
Argon	70 ppm
Water vapor	20 ppm
Carbon monoxide	17 ppm
Helium	12 ppm
Neon	7 ppm
Hydrogen chloride	0.1–0.6 ppm
Hydrogen fluoride	0.001–0.005 ppm

Atmosphere of Venus



Pie chart of the atmosphere of Venus. The chart on the right is an expanded view of the trace elements that all together do not even make up a tenth of a percent.

Atmosphere of Venus

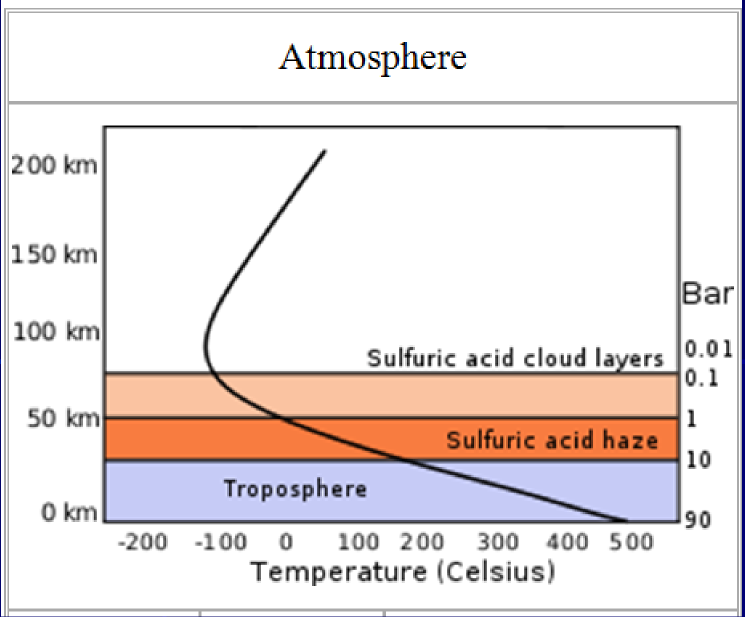
Troposphere

The atmosphere is divided into a number of sections depending on altitude. The densest part of the atmosphere, the troposphere, begins at the surface and extends upwards to 65 km. At the furnace-like surface the winds are slow, but at the top of the troposphere the temperature and pressure reaches Earth-like levels and clouds pick up speed to 100 m/s.

The atmospheric pressure at the surface of Venus is about 92 times that of the Earth, similar to the pressure found 910 m below the surface of the ocean. The atmosphere has a mass of 4.8×10^20 kg, about 93 times the mass of the Earth's total atmosphere.

The large amount of CO2 in the atmosphere together with water vapor and sulfur dioxide create a strong Greenhouse Effect, trapping solar energy and raising the surface temperature to around 740 K (467°C), hotter than any other planet in the solar system.

The **average temperature on the surface** is above the melting points of Lead 600 K (327°C), Tin 505 K (232°C), and Zinc 693 K (420°C).



Atmosphere of Venus

The surface of Venus spends 58.3 days of darkness before the sun rises again behind the clouds.

Height (km)	Temp. (°C)	Atmospheric pressure (x Earth)
0	462	92.10
5	424	66.65
10	385	47.39
15	348	33.04
20	306	22.52
25	264	14.93
30	222	9.851
35	180	5.917
40	143	3.501
45	110	1.979
50	75	1.066
55	27	0.5314
60	−10	0.2357
65	−30	0.09765
70	−43	0.03690
80	−76	0.004760
90	−104	0.0003736
100	−112	0.00002660

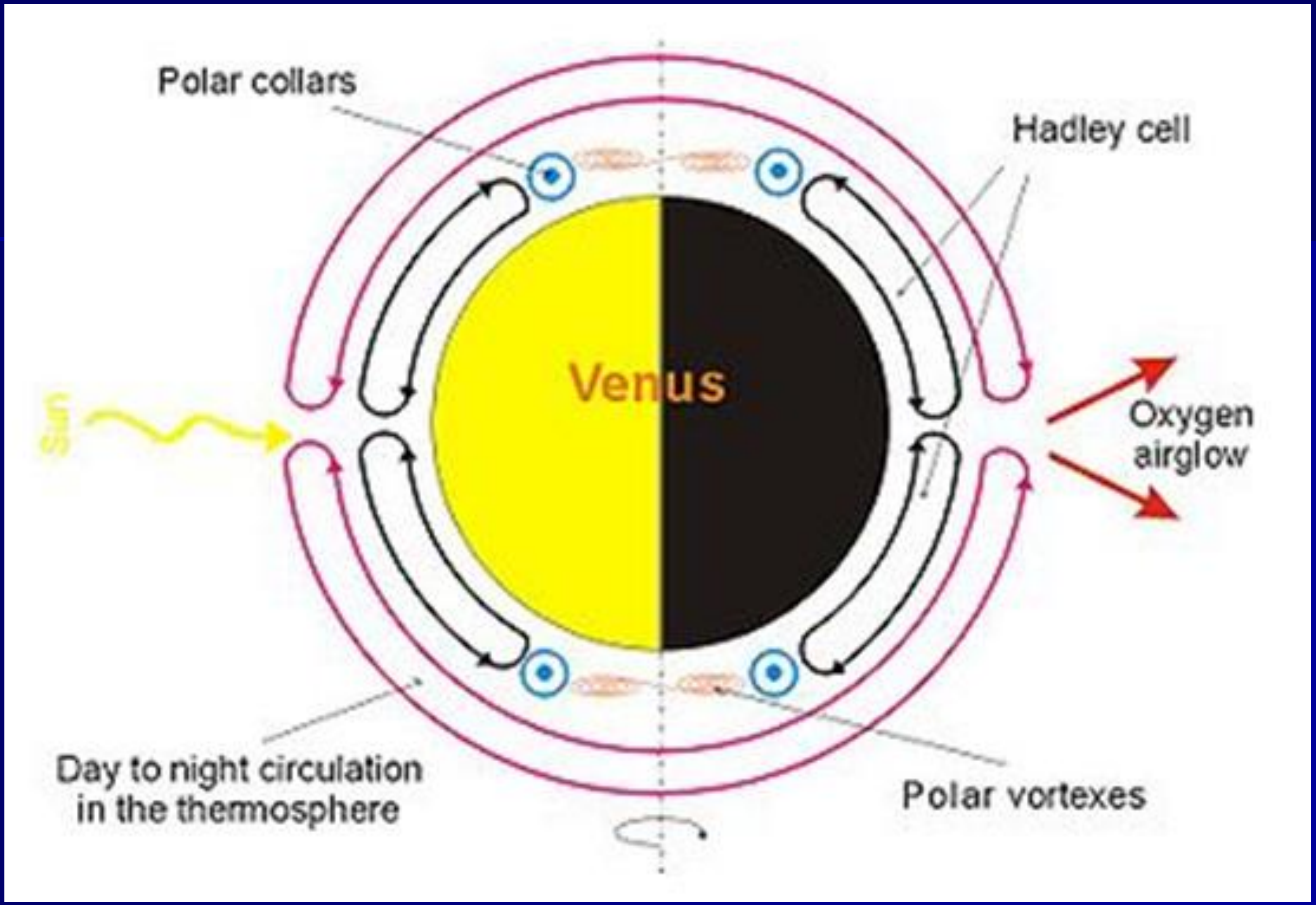
h	T
150	-25
200	50

Atmosphere of Venus

The troposphere on Venus contains 99% of the atmosphere by mass. Ninety percent of the atmosphere of Venus is within 28 km of the surface, by comparison, ninety percent of the atmosphere of Earth is within 10 km of the surface. At a height of 50 km the atmospheric pressure is approximately equal to that at the surface of Earth.

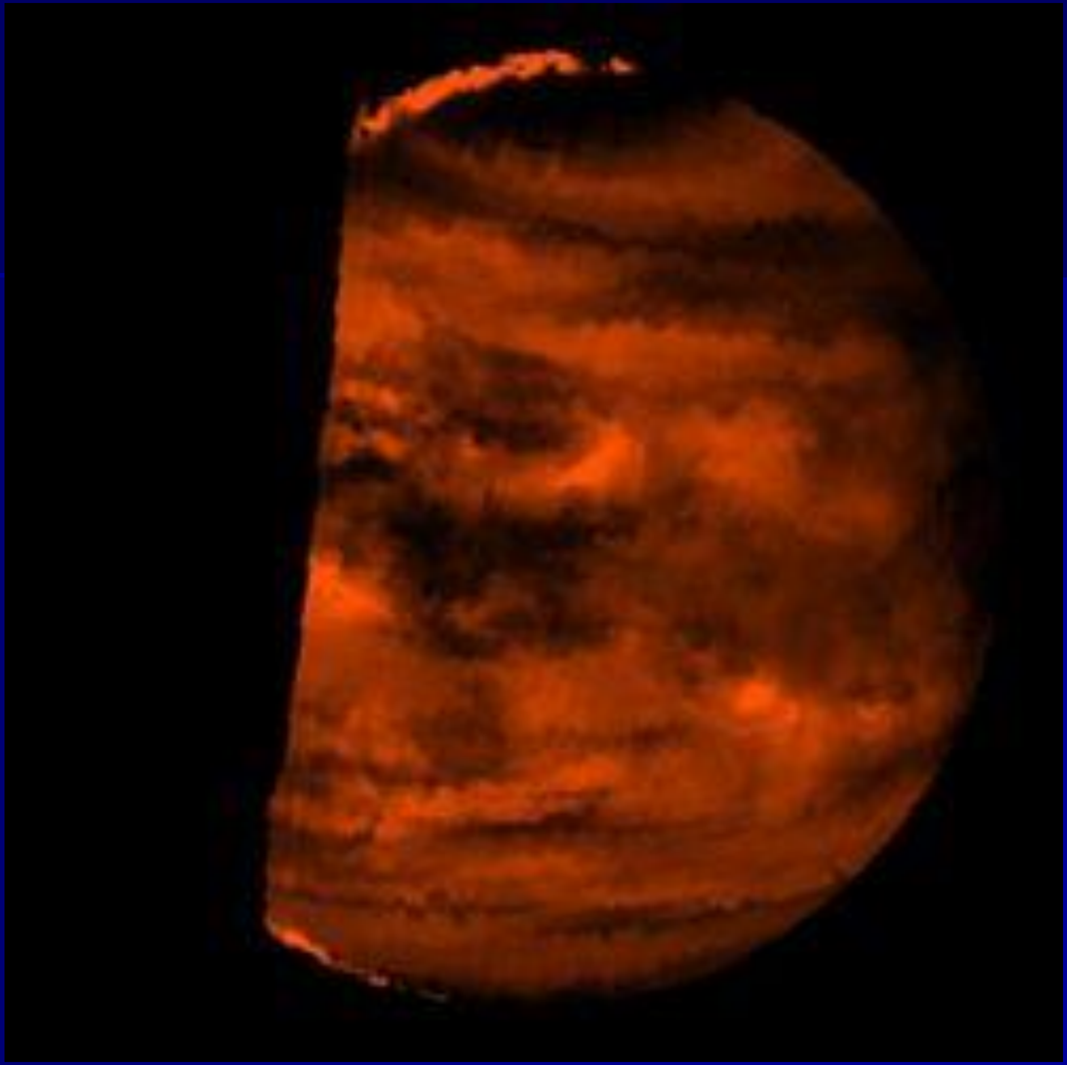
Atmosphere of Venus

Circulation



Meridional (north-south) component of the atmospheric circulation in the atmosphere of Venus. Note that the meridional circulation is much lower than the zonal circulation, which transports heat between the day and night sides of the planet

Atmosphere of Venus



False color near infrared (2.3 μm) image of the deep atmosphere of Venus obtained by Galileo. The dark spots are clouds silhouetted against the very hot lower atmosphere emitting thermal infrared radiation.

Atmosphere of Venus

Upper atmosphere and ionosphere

The mesosphere of Venus extends from 65 km to 120 km in height, and the thermosphere begins at around 120, eventually reaching the upper limit of the atmosphere (exosphere) at about 220 to 350 km. The exosphere is the altitude at which the atmosphere becomes collisionless.

The mesosphere of Venus can be divided into two layers:

the lower one between 62–73 km and the upper one between 73–95 km.
In the first layer the temperature is nearly constant at 230 K (−43°C). This layer coincides with the upper cloud deck.
In the second layer temperature starts to decrease again reaching about 165 K (−108°C) at the altitude of 95 km, where mesopause begins. It is the coldest part of the Venusian dayside atmosphere.

In the dayside mesopause, which serves as a boundary between the mesosphere and thermosphere and is located between 95–120 km, temperature grows up to a constant—about 300–400 K (27–127°C)—value prevalent in the thermosphere. In contrast the nightside Venusian thermosphere is the coldest place on Venus with temperature as low as 100 K (−173°C). It is even called a cryosphere.

Atmosphere of Venus

Upper atmosphere and ionosphere …

Venus has an extended ionosphere located at altitudes 120–300 km. The ionosphere almost coincides with the thermosphere. The high levels of the ionization are maintained only over the dayside of the planet. Over the night-side the concentration of the electrons is almost zero.

The ionosphere of Venus consists of three layers:

v1 between 120–130 km,

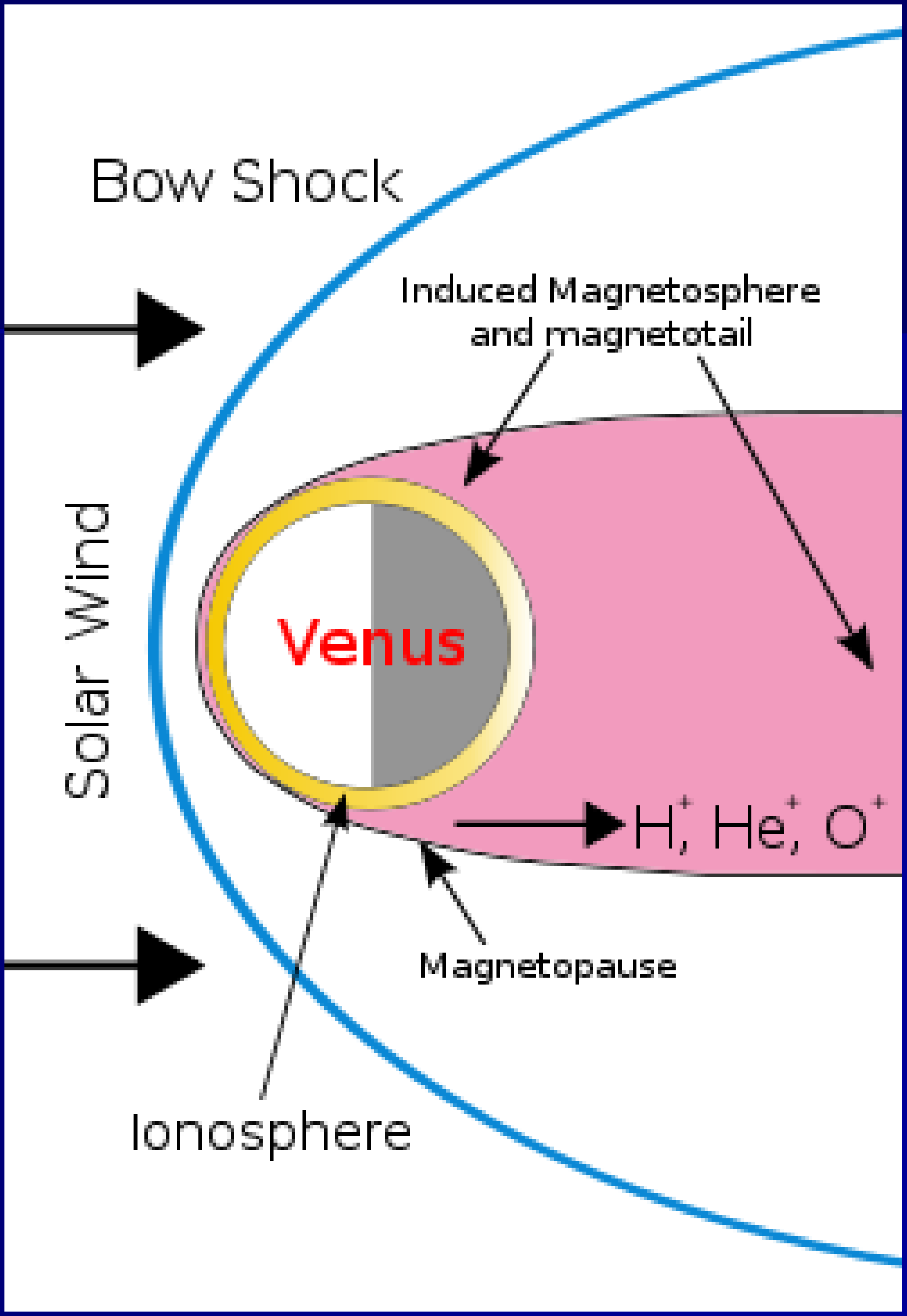
v2 between 140–160 km and

v3 between 200–250 km.

There may be an additional layer near 180 km. The maximum electron volume density 3×10^{11} m^{-3} is reached in the v2 layer near the subsolar point. The upper boundary of the ionosphere—ionopause is located at altitudes 220–375 km and separates the plasma of the planetary origin from that of the induced magnetosphere.

Atmosphere of Venus

Induced magnetosphere



Venus interacts with the solar wind. Components of the induced magnetosphere are shown.

Atmosphere of Venus

Induced magnetosphere

Venus is known not to have a magnetic field. The reason for its absence is not clear, but is probably related to the planet's slow rotation or the lack of convection in the mantle. Venus only has an induced magnetosphere formed by the Sun's magnetic field carried by the solar wind.

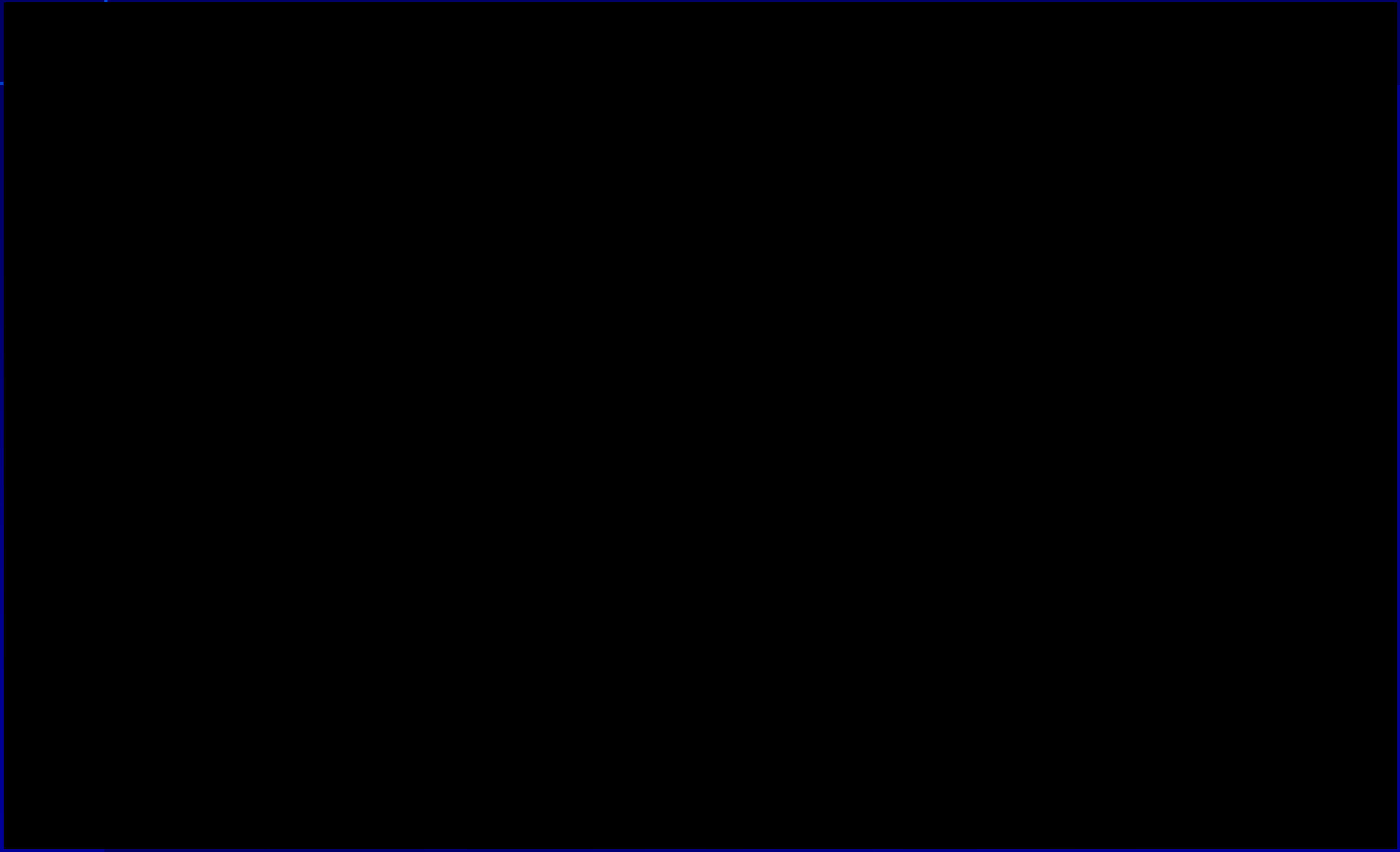
Clouds

Venusian clouds are thick and are composed of sulfur dioxide and droplets of sulfuric acid. These clouds reflect about 75% of the sunlight that falls on them, which is what obscures the surface of Venus from regular imaging.

The **cloud cover is such that very little sunlight can penetrate down to the surface,** and the light level is only around 5,000–10,000 lux with a visibility of three kilometers.

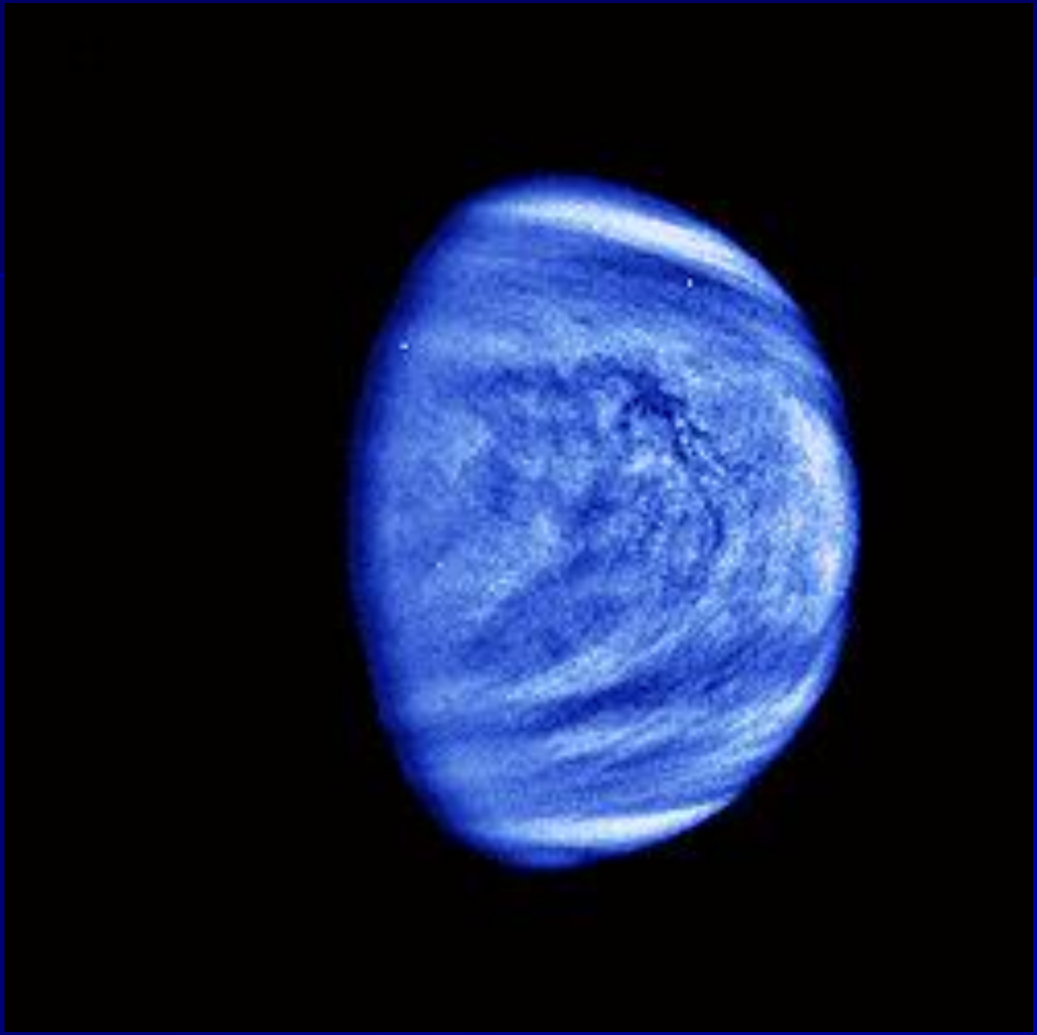
Atmosphere of Venus

Induced magnetosphere



Atmosphere of Venus

Clouds



Photograph taken by the Galileo spacecraft en-route to Jupiter in 1990 during a Venus flyby. Smaller scale cloud features have been emphasized and a bluish hue has been applied to show that it was taken through a violet filter.

Atmosphere of Venus

Sulfuric acid is produced in the upper atmosphere by the Sun's photochemical action on CO2, SO2, and water vapor. UV photons of wavelengths less than 169 nm can photodissociate CO2 into CO and atomic O. Atomic oxygen is highly reactive; when it reacts with sulfur dioxide, a trace component of the Venusian atmosphere, the result is SO3, which can combine with water vapor, another trace component of Venus's atmosphere, to yield sulfuric acid.

$$CO_2 \rightarrow CO + O$$
$$SO_2 + O \rightarrow SO_3$$
$$SO_3 + H_2O \rightarrow H_2SO_4$$

Venus's sulfuric acid rain never reaches the ground, but is evaporated by the heat before reaching the surface in a phenomenon known as virga.

The clouds of Venus are capable of producing lightning much like the clouds on Earth.

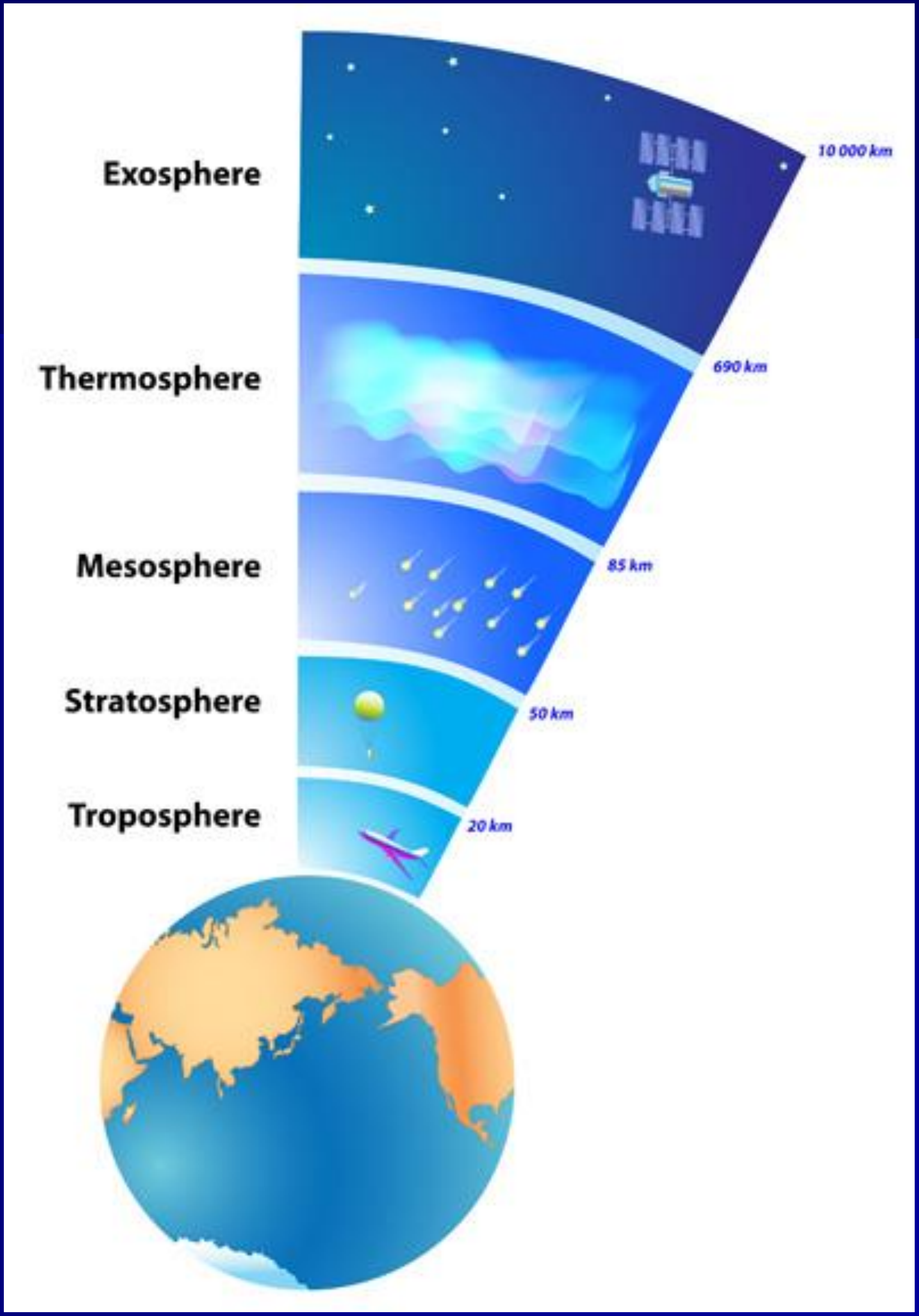
Atmosphere of Earth

Atmosphere of Earth

Atmosphere of Earth

Atmospheric layers

The properties of the Earth's atmosphere vary with altitude. Based on these properties, the atmosphere may be regarded as having different layers or zones. According to one system of nomenclature, there are five layers: the troposphere, stratosphere, mesosphere, thermosphere, and exosphere. The boundaries between these regions are called the tropopause, stratopause, mesopause, and exobase.



Atmosphere of Earth

Troposphere

The troposphere is the atmosphere's lowest and densest layer, and it is also known as the *lower atmosphere*. It starts from the Earth's surface and reaches up to about 7 km at the poles and 17 km at the equator, with some variation caused by weather factors. The upper boundary of this layer is called the *tropopause*.

The temperature of the **troposphere decreases with height**. At middle latitudes, the temperature drops from about +17° C at sea level to about -52° C at the beginning of the tropopause. At the poles, the troposphere is thinner and the temperature falls to only -45° C , while at the equator, the temperature at the top of the troposphere can reach -75° C.

Atmosphere of Earth

Stratosphere

The stratosphere is situated directly above the troposphere and just below the mesosphere. In terms of its altitude range, it lies between about 10 km and 50 km at moderate latitudes, but it starts at about 8 km at the poles. This layer is dynamically stable, with no regular mixing of air and associated turbulence.

The upper layers of the stratosphere are heated by the presence of an Ozone Layer that absorbs UV radiation from the Sun radiation that would otherwise be harmful to living organisms on Earth. The *stratopause* (at the top of the stratosphere) has a temperature of about 270K fairly close to the temperature at ground level.

Commercial airliners typically cruise at an altitude near 10 km in temperate latitudes, in the lower reaches of the stratosphere. In this manner, they avoid the atmospheric turbulence that occurs in the troposphere.

Atmosphere of Earth

Mesosphere

The mesosphere is the layer between about 50 km and about 80–85 km above the Earth's surface. It is sandwiched between the stratosphere and the thermosphere. The temperature in this layer decreases with increasing altitude and can be as low as 200K (≈ -73° C), **varying according to latitude and season.**

Given that it lies between the maximum altitude for most aircraft and the minimum altitude for most spacecraft, this region of the atmosphere is directly accessible only through the use of sounding rockets. As a result, it is one of the most poorly understood regions of the atmosphere.

Atmosphere of Earth

Mesosphere….

Millions of meteors burn up daily in the mesosphere, as a result of collisions with the gas particles contained there, leading to a high concentration of iron and other metal atoms. The collisions almost always create enough heat to burn the falling objects long before they reach the ground. Thus the mesosphere protects the Earth from a barrage of would-be meteorites.
The stratosphere and mesosphere are referred to as the *middle atmosphere*. Regions above the mesosphere are called the *upper atmosphere*.

The *mesopause*, at an altitude of about 80 km, separates the mesosphere from the thermosphere. The mesopause lies near the *turbopause*, the band below which different chemical species are well mixed by turbulent eddies.

Atmosphere of Earth

Thermosphere

The thermosphere extends from an altitude of 80–85 km to 640+ km. It lies directly above the mesosphere and right below the exosphere.

At these high altitudes, the residual atmospheric gases sort into strata according to their molecular masses. The temperature in this layer increases with altitude, **due to the absorption of extremely energetic solar radiation by the small amount of oxygen present.** Temperatures are highly dependent on solar activity and can rise to 2,000° C. Solar radiation causes the air particles in this layer to become ionized, that is, electrically charged.

Astronauts travel at altitudes that exceed 80 km, which means that they travel within or go beyond the thermosphere. An altitude of 120 km marks the boundary where atmospheric effects become noticeable during re-entry.

Atmosphere of Earth

Exosphere

The exosphere is the uppermost layer of the atmosphere. Its lower boundary at the edge of the thermosphere is estimated to be 500 km to 1,000 km above the Earth's surface, and its upper boundary at about 10,000 km.

It is only from the exosphere that atmospheric gases can, to any appreciable extent, escape into outer space. The main gases in the exosphere are the lightest ones, mainly hydrogen and helium, with some atomic oxygen near the exobase (the lowest altitude of the exosphere). The few particles of gas here can reach 2,500° C during the day.

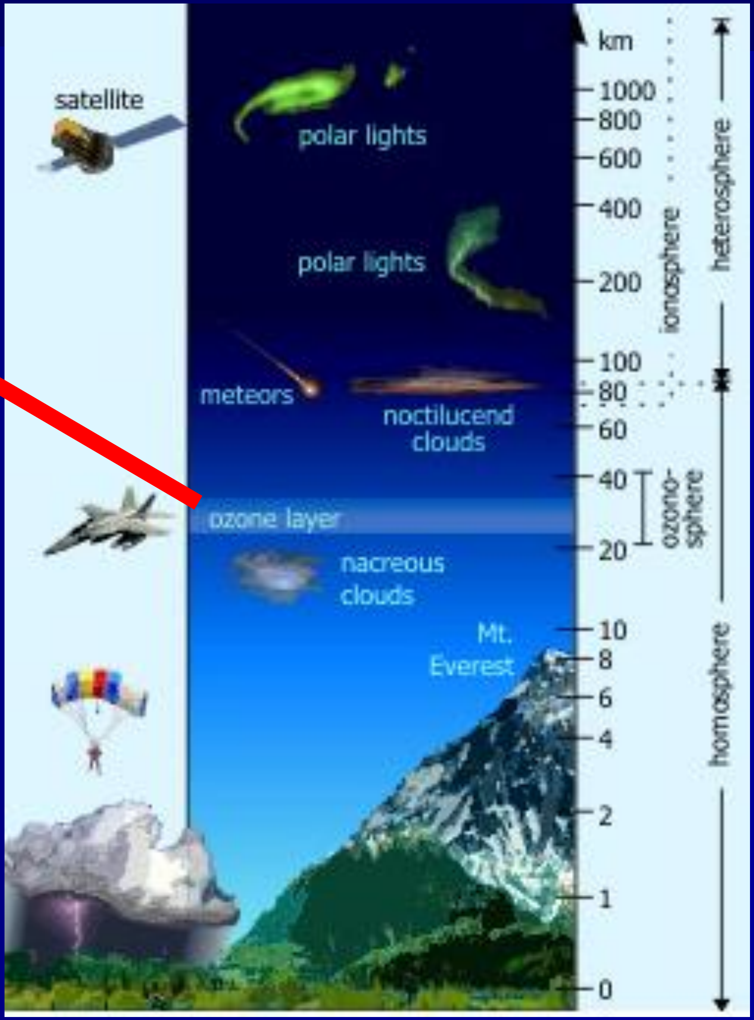
Atmosphere of Earth

Additional atmospheric regions

Atmospheric regions are also named in other ways, as follows.

Ozone layer (Ozonosphere):

In the stratosphere, in an altitude range of about 10–50 km, the concentration of ozone (O3) is a few parts per million, which is much higher than the ozone concentration in the lower atmosphere **This layer, absorbs biologically harmful UV radiation from the Sun**.



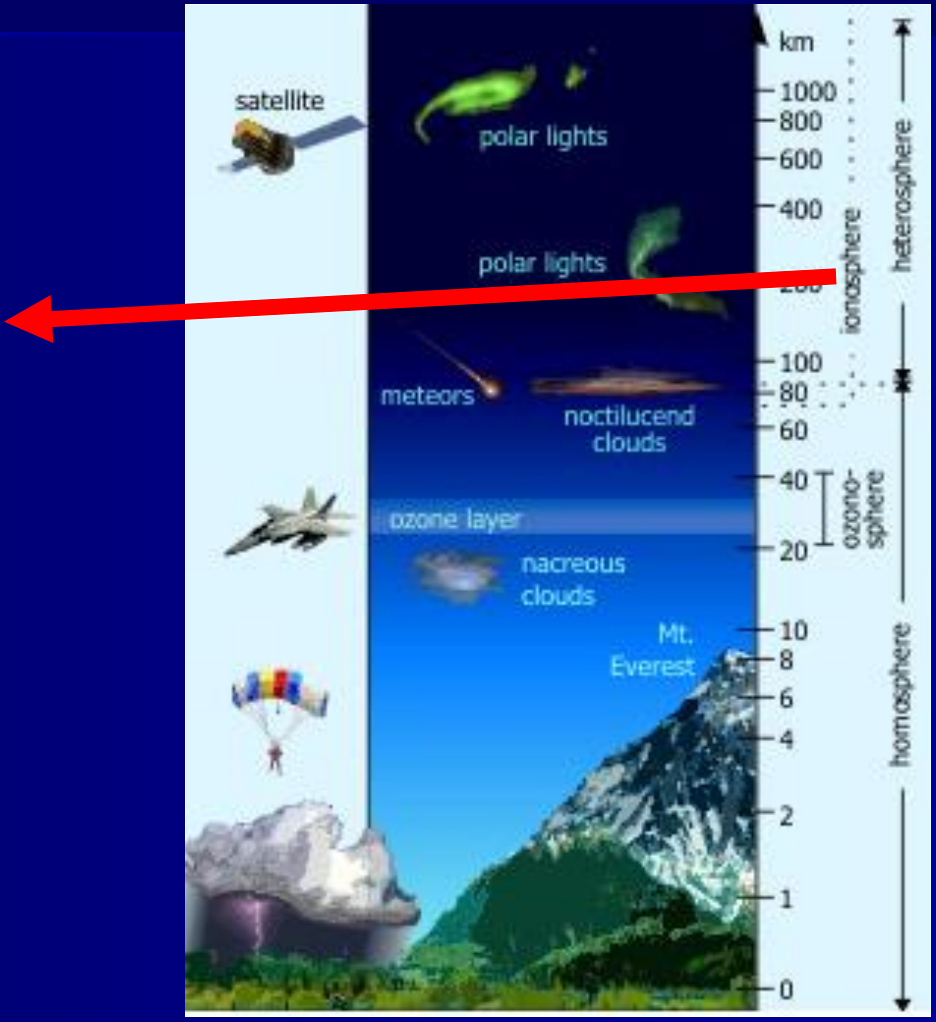
Atmosphere of Earth

Additional atmospheric regions

Atmospheric regions are also named in other ways, as follows.

Ionosphere:

This is the region of the atmosphere that contains ions (that form a "plasma"), created by the interaction of solar radiation with gas particles.



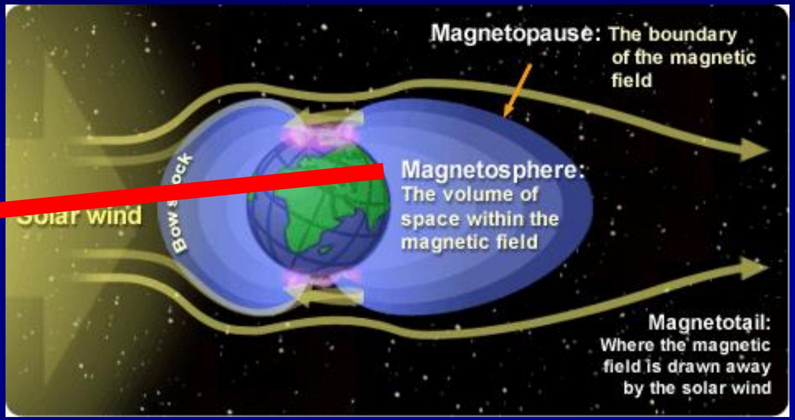
Atmosphere of Earth

Additional atmospheric regions

Atmospheric regions are also named in other ways, as follows.

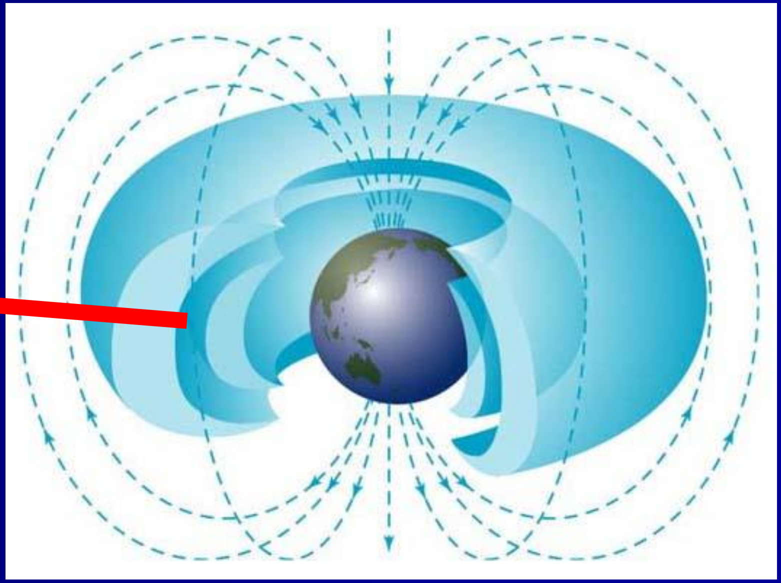
Magnetosphere:

It is the region where the Earth's magnetic field interacts with the solar wind.



Van Allen radiation belts:

These are regions where charged particles (forming a plasma) from the solar wind are trapped by the Earth's magnetic field.



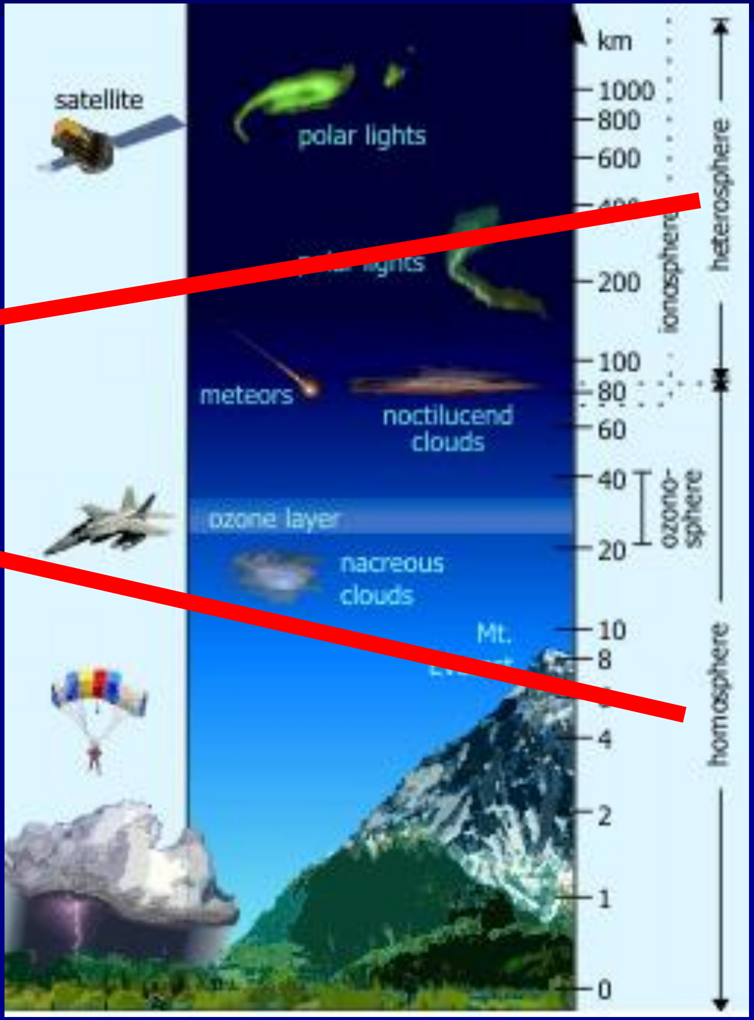
Atmosphere of Earth

Additional atmospheric regions

Atmospheric regions are also named in other ways, as follows.

Homosphere (or Turbosphere) and Heterosphere:

The region below the turbopause (that is, below an altitude of about 100 km) is known as the *homosphere* or *turbosphere*, where the chemical constituents are well mixed and the composition of the atmosphere remains fairly uniform.



Atmosphere of Earth

Pressure, density, and mass

Atmospheric pressure (or barometric pressure) is a direct result of the weight of the air. It is highest at the Earth's surface and decreases with altitude. This is because air at the surface is compressed by the weight of all the air above it. Air pressure varies with location and time, because the amount (and weight) of air above the Earth varies with location and time.

Atmospheric pressure drops by approximately 50 percent at an altitude of about 5 km. The average atmospheric pressure at sea level is about 101.3 kilopascals.

The density of air at sea level is about 1.2 kg/m3, and it decreases as altitude increases.

The average mass of the atmosphere is about 5,000 trillion metric tons.

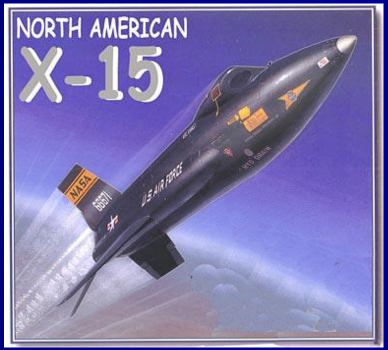
Atmosphere of Earth

Thickness of the atmosphere

57.8 percent of the atmosphere is below the summit of Mount Everest.

72 percent of the atmosphere is below the common cruising altitude of commercial airliners (about 10,000 m).

99.99999 percent of the atmosphere is below the highest flight altitude of the aircraft X-15, which reached 108 km on August 22, 1963. Therefore, most of the atmosphere (99.9999 percent) is below 100 km, although in the rarified region above this there are auroras and other atmospheric effects.

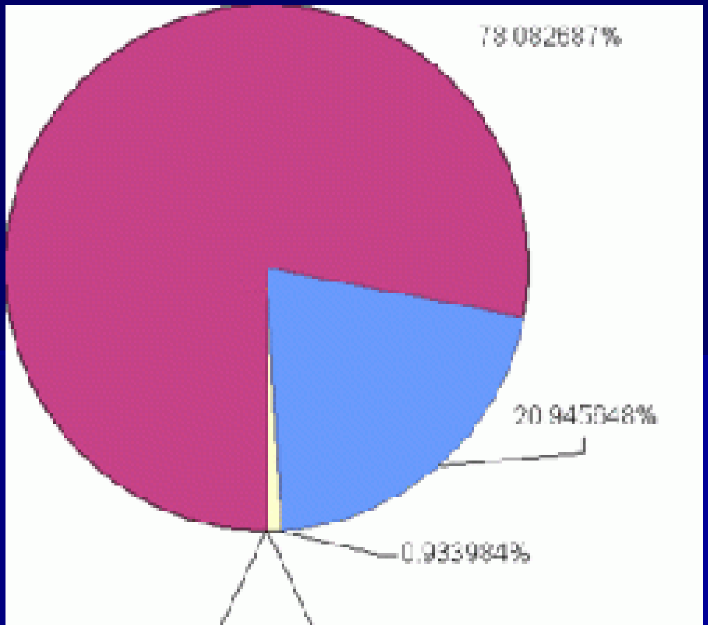


The atmosphere exists at altitudes of 1,000 km and higher, but it is so thin as to be considered nonexistent.

Atmosphere of Earth

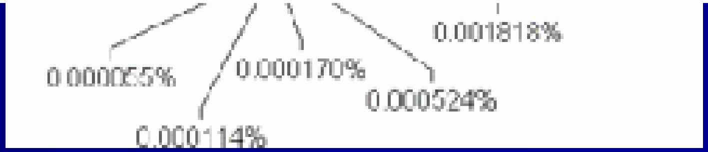
Composition of the atmosphere

Composition of dry atmosphere (homosphere), by volume	
ppmv: parts per million by volume	
Gas	**Volume**
Nitrogen (N_2)	780,840 ppmv (78.084%)
Oxygen (O_2)	209,460 ppmv (20.946%)
Argon (Ar)	9,340 ppmv (0.9340%)
Carbon dioxide (CO_2)	350 ppmv
Neon (Ne)	18.18 ppmv
Helium (He)	5.24 ppmv
Methane (CH_4)	1.745 ppmv
Krypton (Kr)	1.14 ppmv
Hydrogen (H_2)	0.55 ppmv
Not included in above dry atmosphere:	
Water vapor (highly variable)	typically 1%



Minor components of air not listed above include:

Gas	**Volume**
nitrous oxide	0.5 ppmv
xenon	0.09 ppmv
ozone	0.0 to 0.07 ppmv
nitrogen dioxide	0.02 ppmv
iodine	0.01 ppmv
carbon monoxide	trace
ammonia	trace



Atmosphere of Earth

Biological significance

The Earth's atmosphere plays a vital role in sustaining life on this planet. **Oxygen is needed for respiration by animals, plants, and some bacteria.**

Plants that perform **photosynthesis** take up carbon dioxide from the air and release oxygen.

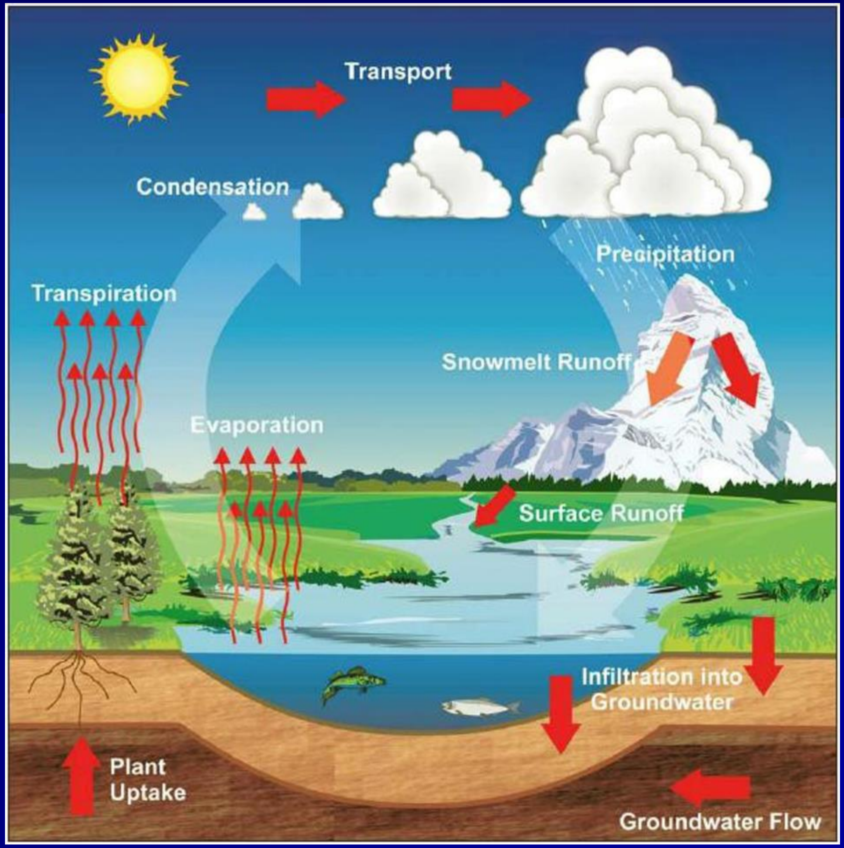
Carbon dioxide and water vapor act as "greenhouse gases" that keep the Earth sufficiently warm to maintain life.

Atmosphere of Earth

Biological significance

Water vapor in the air is part of the water cycle that produces **precipitation** (such as rain and snow) that replenishes **moisture in the soil**.

In addition, water vapor prevents **exposed living tissue** from drying up.

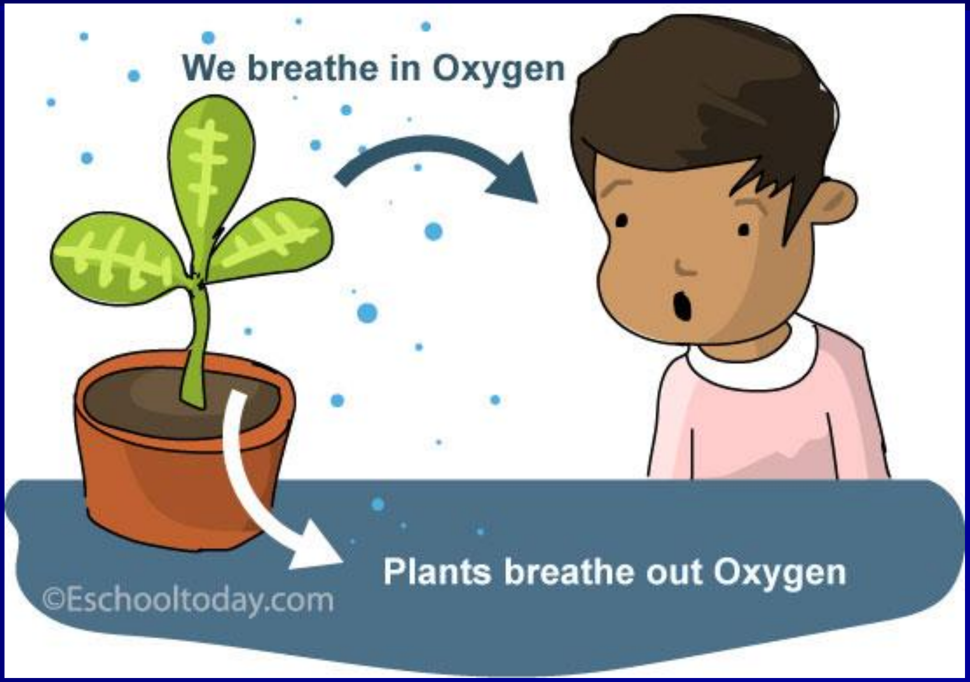


Atmosphere of Earth

Biological significance

Oxygen & Water

Oxygen helps organisms grow, reproduce, and turn food into energy. Humans get the oxygen they need by breathing through their nose and mouth into their lungs. Oxygen gives our cells the ability to break down food in order to get the energy we need to survive.



Atmosphere of Earth

Biological significance

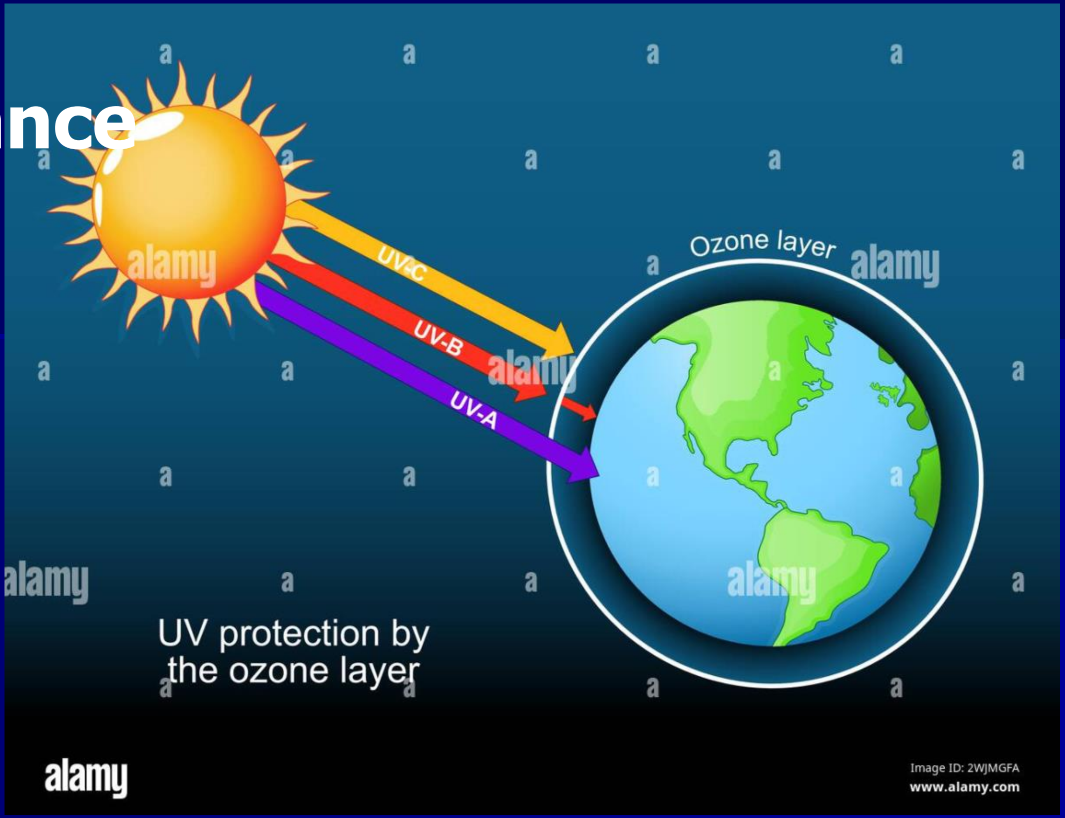
Oxygen & Water

On a biological level, **water**'s role as a solvent helps cells transport and use substances like oxygen or nutrients. Water-based solutions like blood help carry molecules to the necessary locations.

Atmosphere of Earth

Biological significance

Ozone Layer



The ozone layer **protects us from the UV radiation**, known as UV-B, which causes sunburn. Long-term exposure to high levels of UV-B threatens human health and damages most animals, plants and microbes, so the ozone layer protects all life on Earth.

Atmosphere of Earth

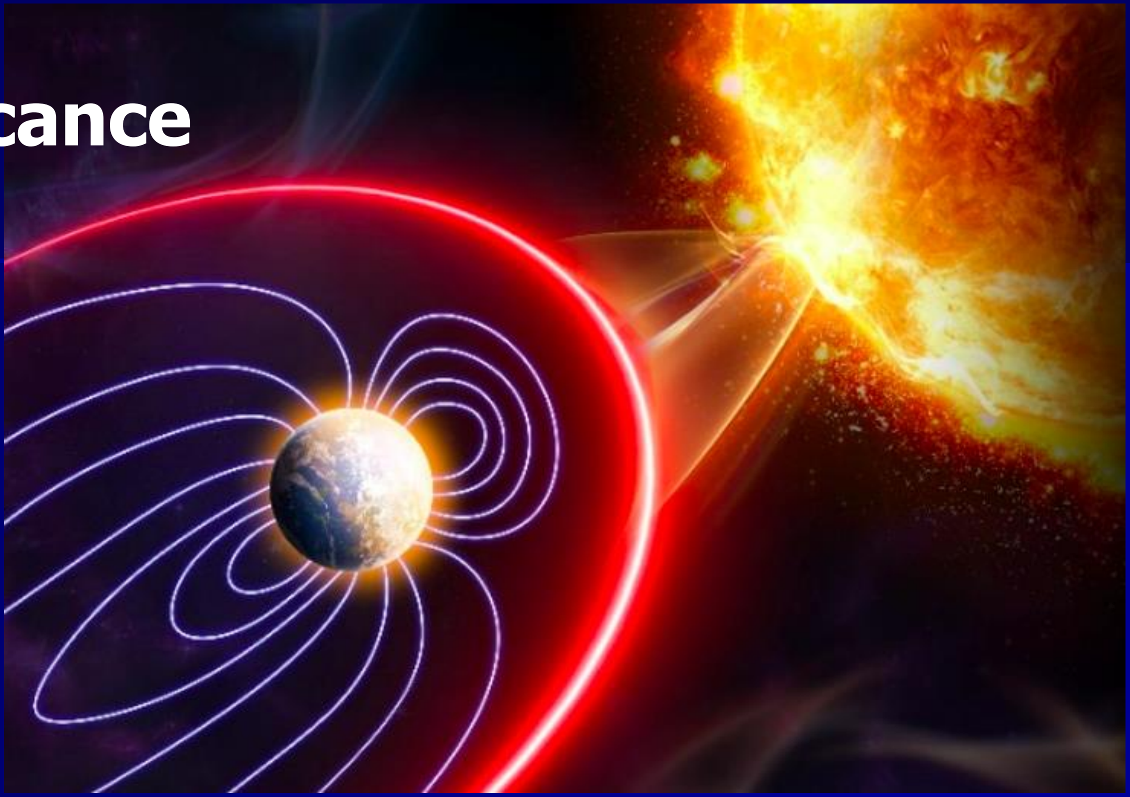
Biological significance

Gravity

We could not live on Earth without it. The sun's gravity keeps Earth in orbit around it, keeping us at a comfortable distance to enjoy the sun's light and warmth. It holds down our atmosphere and the air we need to breathe. Gravity is what holds our world together.

Atmosphere of Earth

Biological significance



Magnetic Field

Generated by the motion of molten iron in Earth's core, the magnetic field protects our planet from cosmic radiation and from the charged particles emitted by our Sun

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Atmosphere of Earth

Air pollution

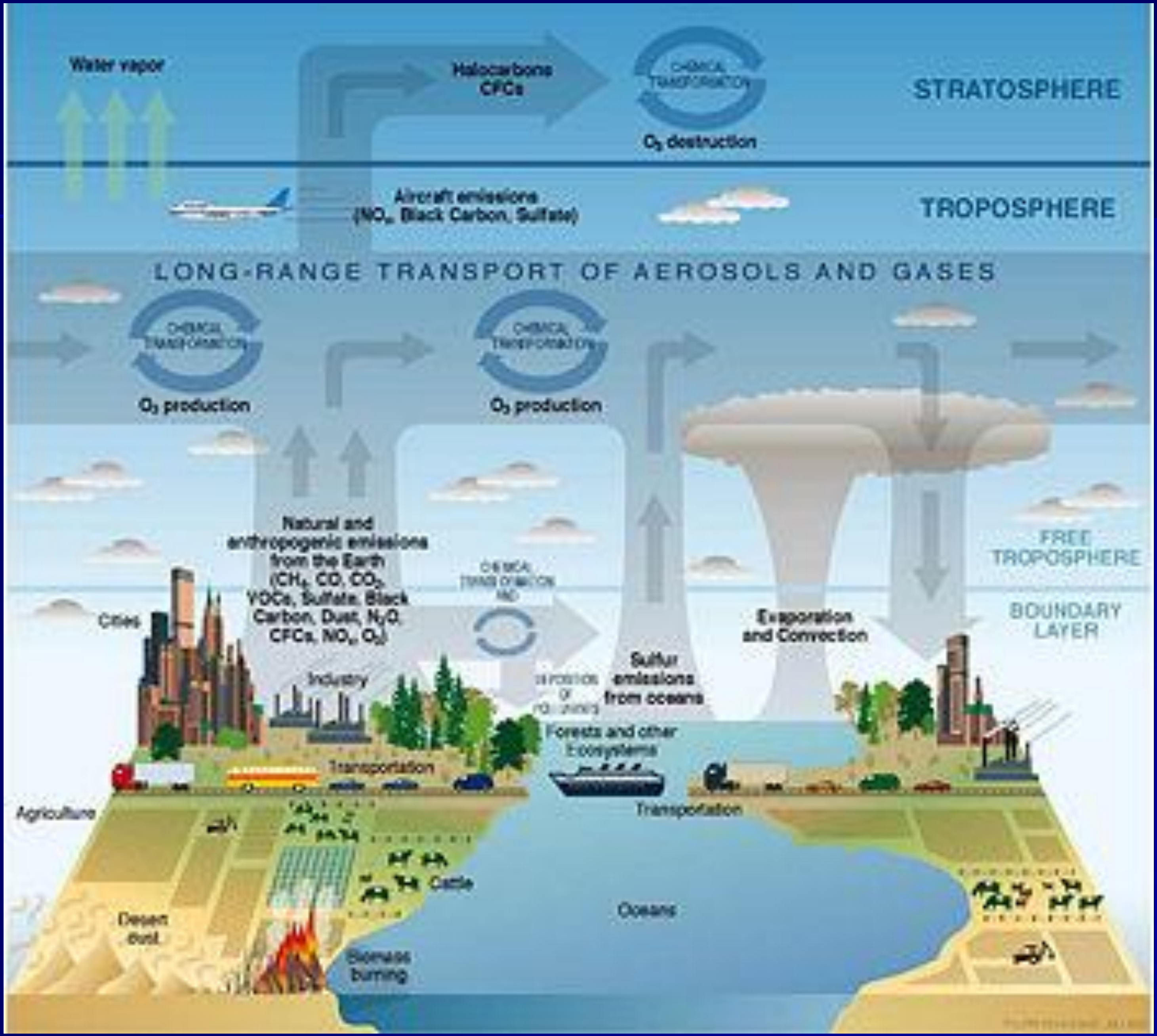
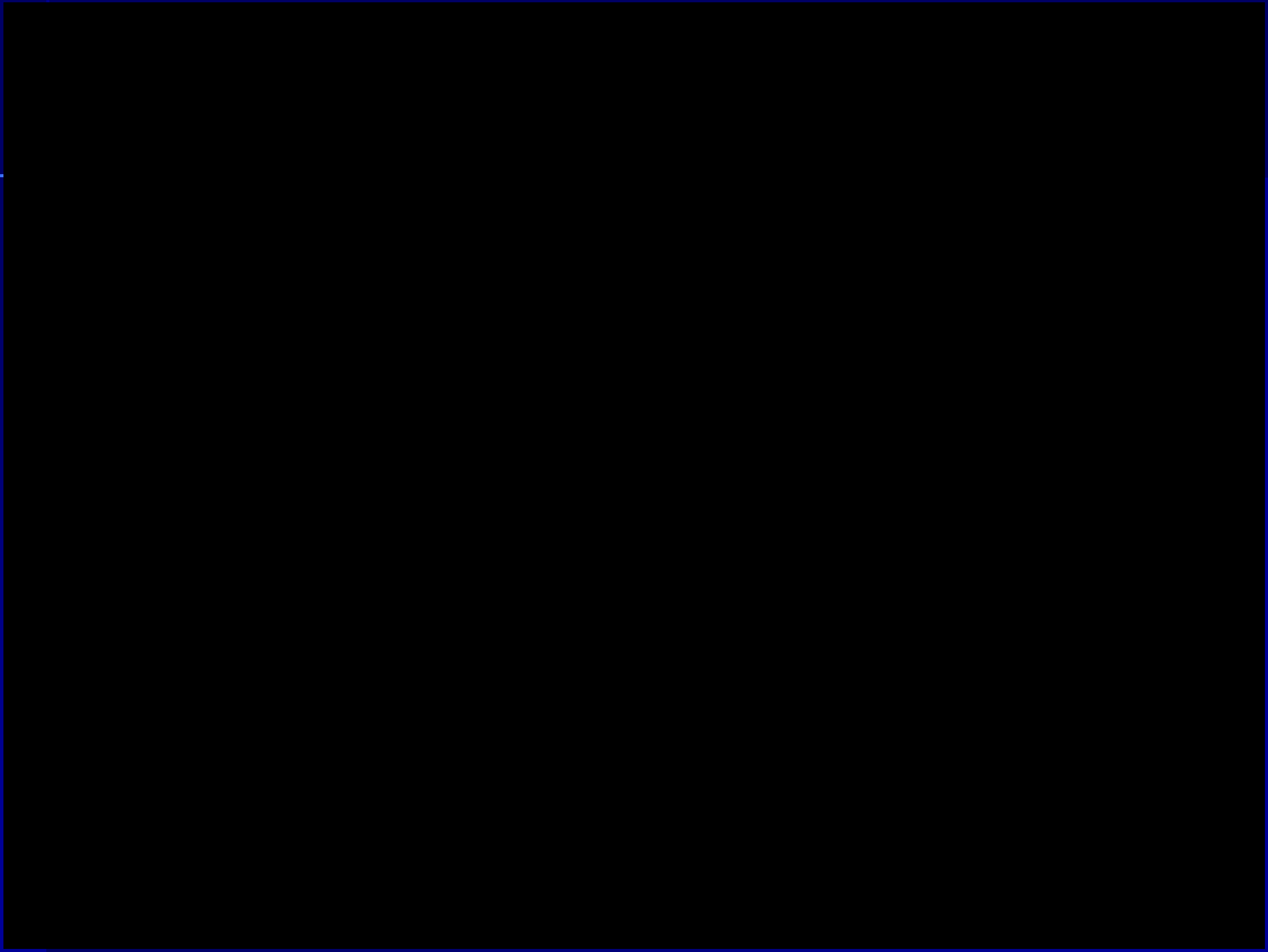


Diagram of chemical and transport processes related to atmospheric composition.

Atmosphere of Earth

Air pollution



Atmosphere of Earth

Air pollution

Although technological advances have benefited humankind in numerous ways, they have been accompanied by adverse effects on the environment, including pollution of the air.

Common air pollutants include carbon monoxide (**CO**), nitrogen oxides (NOx), sulfur oxides (SOx), ozone, and particulate matter (PM). They are generally produced by such activities as

(a) combustion (burning) of fuels for transportation and the generation of heat and electricity, and

(b) industrial processes, including petroleum refining, cement manufacturing, and metal processing.

Atmosphere of Earth

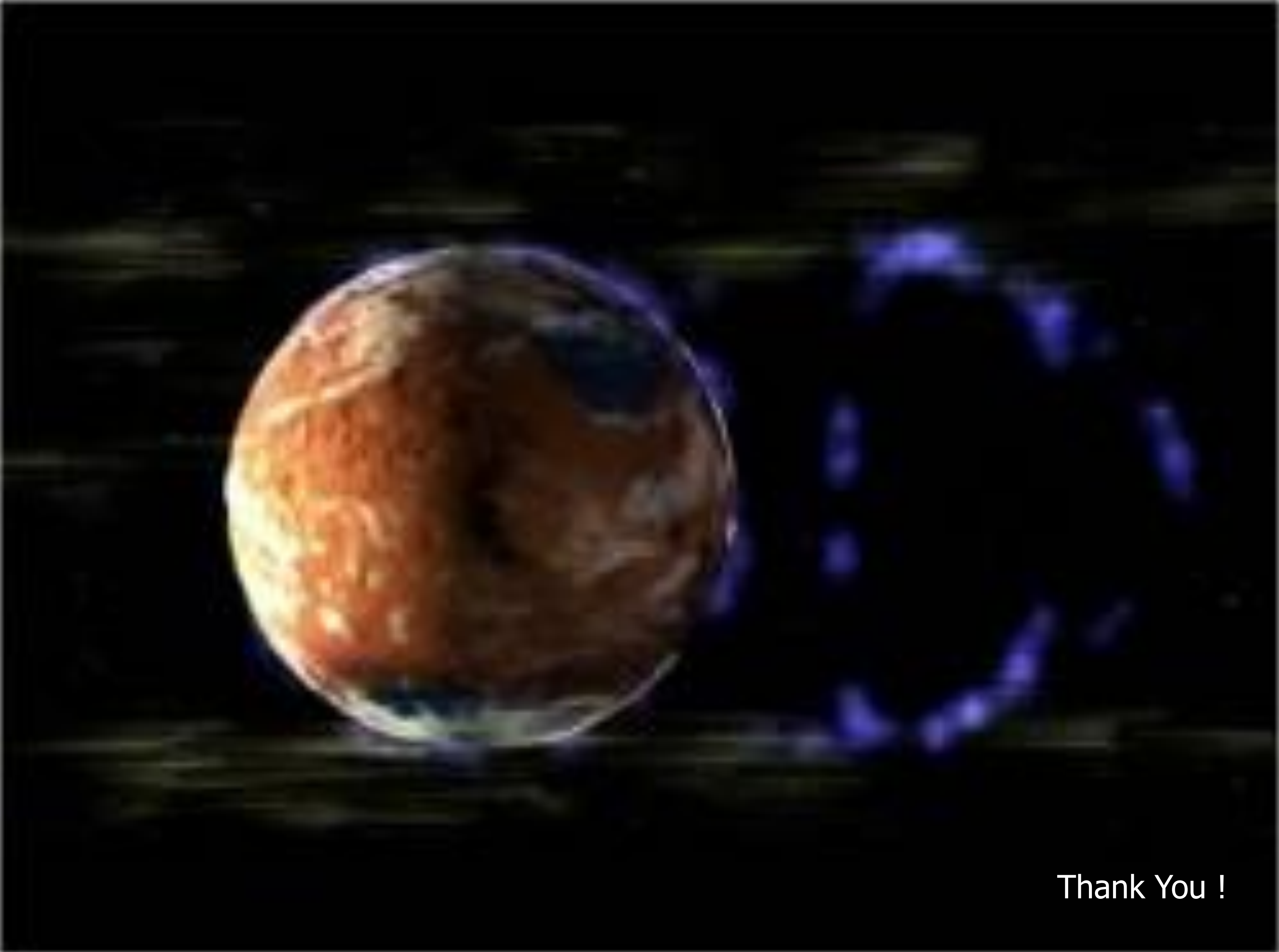
Air pollution

To reduce such pollutants, the governments of various nations have mandated measures such as the use of reformulated gasoline, catalytic converters in motor vehicle exhaust systems, and effluent traps for industrial wastes.

In addition to the problem of pollution, there is concern that global temperatures are rising as a result of increasing levels of greenhouse gases such as carbon dioxide and methane in the atmosphere.

Atmosphere of Earth

Air pollution : UN issues warning over air pollution



Thank You !