



Tananyag fejlesztés idegen nyelven

Prevention of the atmosphere

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Szociális Alap társfinanszírozásával valósul meg



Fundamentals of the place of atmospheric contamination I.

Lecture 1
Lessons 1-3



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Lesson 1

The spheres, the atmosphere included Components of the atmosphere



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Definition of the atmosphere

- The gas shell surrounding our planet Earth is called atmosphere. The atmosphere is a mixture of gases of different compositions, included some water as vapour, liquid, or solid state, and suspended particles of various natures. The liquid and solid components comprise the so called atmospheric aerosols. They are of very small size gently suspended in the air. As their size is small, in general we can't see them. In bright sunshine, for a shorter time period the largest sized particles ad interim can be detected by our eyes. These are the flying dusts.



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In atmospheric pollution or protection, the name of particles is more frequently applied than the denomination of atmospheric aerosol. Both of them are in every day usage.

The Earth together with its atmosphere may be divided into five spheres of very different nature as follows:

- hydrosphere
- atmosphere
- lithosphere
- biosphere and
- cryosphere



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In some publications this latter cryosphere belongs to the hydrosphere. All the spheres are present in the environment together, even their separation may be problematic; for example the soil almost always contains more or less air in their pores. And what is the happening with caves?



Fig. 1 The spheres, the atmosphere included
(www.ofi.hu/tudastar/globalis/2-eghajlati-rendszer)



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Among the five spheres the hydrosphere is the sum of oceans, seas, rivers, lake waters (over the surface and under the ground water). The Earth's *hydrosphere* mass is about 1.4×10^{18} t, only a very small part of the Earth mass (0.02%). The mass of oceans is more than 200 times as large as the mass of the atmosphere. Almost two third of the whole Earth surface is covered by the oceans and seas. Their surface area is 360 million square kilometers. The majority of water is salty water, only a few per cent of it is the drinking or sweet water. The reason why the protection of the sweet water has of primary importance is the scarcity of drinking water.



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Table 1 Reservoirs of water: masses averaged over the Earth surface (in 10^3 kgm^{-2}) and their residence time (Wallace and Hobbs)

Reservoir	Mass	Residence time
Atmosphere	0.01	9-10 days
Lakes, rivers	0.6	days-years
Underground w.	15	up to 100 of years
Glaciers	0.2	”
Ice sheet (Greenland)	5	10,000 years
Ice sheet (Antarctic)	53	100,000 years
Oceans	2,700	
Crust and mantle	20,000	10^{11} years



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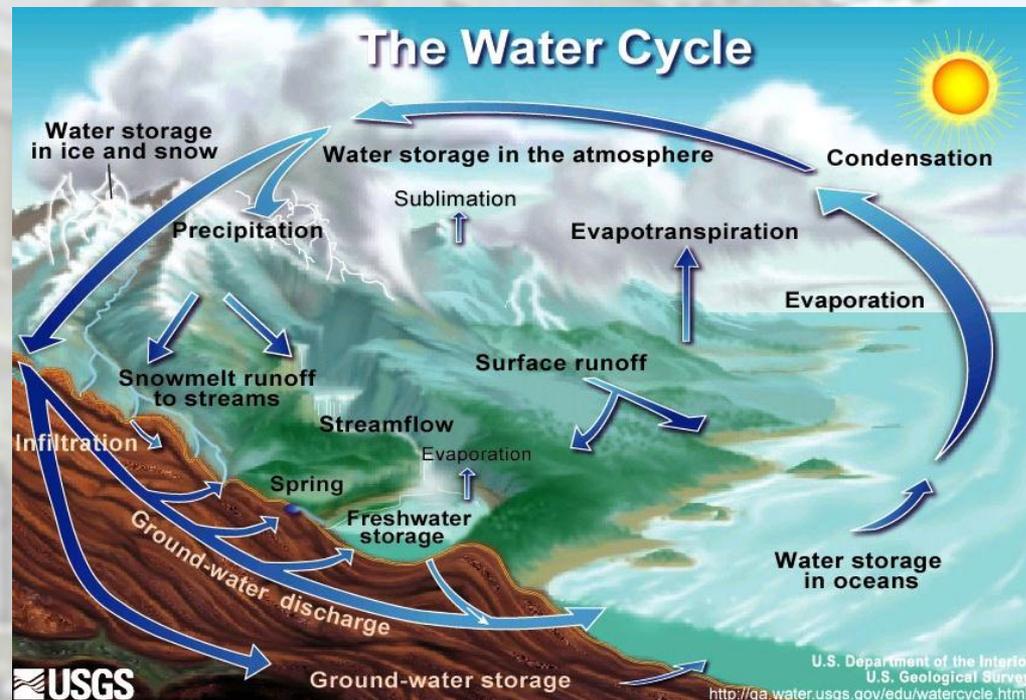
Denomination of the Earth as the “Blue planet” is due to the dominating size of water surfaces. This name was given by the astronauts glancing the dominant blue color from the space.



Fig. 2 The blue planet

(<http://www.prelovac.com/vladimir/wp-content/uploads/2008/03/pretty-blue-planet.jpg>)

Fig. 3 Relationship between the elements of hydrosphere is discussed in hydrological cycle



en.wikivisual.com/index.php/Hydrologic_cycle



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- The *lithosphere* is the sum of dry-lands, it comprises at about one third of the whole planet's surface. In contrary to hydrosphere, which is a homogenous surface, the lithosphere is heterogenic. Due to this difference their physical and heat properties are greatly varied.
- The *biosphere* is the aggregation of living organisms, and the humans are also included. The group is very colourful relating the component's nature.
- The *cryosphere* describes the portions of the Earth's surface where water is in solid form for the whole season. The permanent ice is located on the poles. The water storage in the cryosphere is equal to the water of the lithosphere, it's only a couple of %.





All of the mentioned five spheres are endangered of human induced artificial contamination. Although there is a close connection between the spheres in nature , the relationship among them is interaction. In environmental studies, the pollution of the spheres used to discuss more or less separately; we speak about

- Atmospheric pollution (protection)
- Soil contamination
- Water pollution

In our subject we focus on the process of atmospheric pollution, but it is evident that the phenomenon is not independent on the happening of the other spheres





The ***composition of the atmosphere*** is known from the earlier studies. The widely used categories regarding the residence time of gases are discussed in every notebook partially. The environmental protection uses two parts of air components; the main gases (N_2 and O_2 ; sometimes plus Ar) and the ***traces***. The traces, the only possible pollutants, may be gases, aerosols and condensed water. Due to their different character, we have to distinguish the water and aerosol.

- The aerosols are liquid and solid particles in suspension
- The condensed water contains liquid (cloud and rain drops) and solid (snow and graupel) forms of water.





Table 2 The characteristic size of traces after Sportisse

<u>Atmospheric “body”</u>	<u>Size</u>
Gaseous molecule	0.1 nm (<i>Angström</i>)
Fine aerosol	1 nm–1 μm
Coarse aerosol	10–20 μm
Cloud drop	10–50 μm
Rain drop	0.1mm

First approximation in case of pollutant is the sphere shape. Sometimes it may be quite different!



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Lesson 2

Traces in the air. Some calculations of the physical properties of the atmosphere



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*The most important **traces**, their origin after Sportisse:*

- sulfur dioxide (SO_2), related to fossil fuel combustion
- gas-phase photochemical compounds: ozone (O_3), nitrogen oxides (NO and NO_2), volatile organic compounds (VOC)
- heavy metals (lead, cadmium, zinc etc.), related to industrial emissions (also on the surface of particulates)
- mercury (Hg) in gaseous and particulate phase;
- aerosols (particulate matter), composed of a mixture of sulfate (SO_4^{2-}), ammonium (NH_4^+), nitrate (NO_3^-), organic matter, dust, sea salt and liquid water





- radionuclides, related to natural emissions (radon); the others come from the atmospheric nuclear tests (strontium), or accidental releases (iodine, cesium) or origins from nuclear industry (krypton)
- greenhouse gases: CO₂, methane, nitrogen protoxide (N₂O), Chlorofluorocarbons (freons), ozone
- carbon monoxide (CO);
- persistent organic pollutants (POP), pesticides, dioxin



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The existence of **aerosols** in the atmosphere may be useful or detrimental. The Earth precipitation events could be scarce without aerosols. The aerosol serves as condensation nuclei when the water vapor forms a water film on the surface of the particulate.

Increasing aerosol concentration above a threshold limit causes environmental harm. It may be intensified when heavy metals and radioactive materials are bounded on the surface of the particles.

The ratio of acid rains rises on those areas, where the amount of aerosols is higher.





Due to more intense aerosol production the existence of fogs is also increasing.

Except of main constituents of the air (the nitrogen and oxygen molecule of two atoms), all the other materials, the gases, particles of solid and liquid forms are included in trace materials. They may become pollutants at special circumstances (at increasing particulate concentration and/or higher residence time).





Let's calculate the total mass of the atmosphere!

1. The basis of assumption is the *air pressure* definition (p); exerted by a downward force of 1 Newton evenly distributed over an area of 1 m² due to the gravitation [Pa]
2. Second step its extension for the total *Earth surface* (A)
3. The last step is the account of *gravitation* (g)

$$m = \frac{p \cdot A_{earth}}{g}$$





Required data and knowledge

A: Earth surface (do not forget in case of spherical
 $= 4r^2\pi$)

where

r : 6378 km = 6.378×10^3 km = 6.378×10^6 m

p : mean air pressure at sea level (1013 hPa=mb)

*Meaning of prefix **hecto**(Pa): one hundred= 10^2*

g : gravitation (9.81 m/s²)





Calculation of the surface of the planet

$$\begin{aligned}
 \text{Earth surface: } 4r^2\pi &= 4 \times (6.378 \times 10^6)^2 \times \\
 3.14 &= \\
 &= 4 \times 6.378^2 \times (10^6)^2 \times 3.14 = 5.1 \times 10^{14} \text{m}^2
 \end{aligned}$$

Be careful with powers!

$$(10^6)^2 = 10^{(6 \times 2)} = 10^{12}$$





Where is the mass unit?

Force: required to accelerate a body having a mass of 1 **kg**
at 1 m per second² [N!]

And how is with the pressure unit Pa and N:

$$p = \frac{F}{A} = \left[\frac{N}{m^2} \right] = Pa$$

The final result for the atmospheric mass is:

$$\frac{1013 \times 100 \text{ kg} / \text{m} / \text{s}^2 \times 5.1 \times 10^{14} \text{ m}^2}{9.81 \text{ m} / \text{s}^2} = 5.26 \times 10^{18} \text{ kg}$$

It is only one millionth of the total Earth mass (10²⁴kg).





- How thick is the atmosphere?

We know the mean air pressure pushing the unit surface of the Earth, and the air weight may also be calculated. The weight of air on 1m² is about 10⁴kg. The average air density at the sea level is also known, 1.3kg/m³. The volume of air (V) will be the air mass (m) dividing with air density (ρ):

$$V = \frac{m}{\rho} = \frac{10^4 \text{ kg}}{1.3 \text{ kgm}^{-3}} = 7692 \text{ m}^3$$



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As we know the definition of the air pressure (force on unit surface, for 1m^2), the extension of the atmosphere will be sharply **7692m**.

This is a simplified and not completely precise calculation, because the vertical change in air pressure was not considered in the evaluation. In reality the half of the whole atmospheric mass can be found below 5.5km level, and the three fourth of it below 11km.

The upper limit of the atmosphere is not known. The evaluated border can be found somewhere about 1000 km from the surface.





Lesson 3

The vertical stratification of the atmosphere Characterization of the air layers



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Vertical structure of the atmosphere; the air stratification

On the basis of molecular weight

In the atmosphere the composition of the lower layers is more or less constant, because of mixing of turbulent air motions (below 80-100km). Above this height limit, the mean free path between molecules increases, and the concentration of heavier molecules drops exponentially, more quickly as the lighter ones do. In the air above 100km the light molecules of helium and hydrogen will be dominant. The atmosphere above 80-100km is called heterosphere.



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Only the hydrogen is able to escape from the atmosphere when the sun radiation is extremely intense.

The lower 80-100km of the atmosphere, where the well known composition detected is called homosphere. Here the turbulence and molecular mixing are dominant.

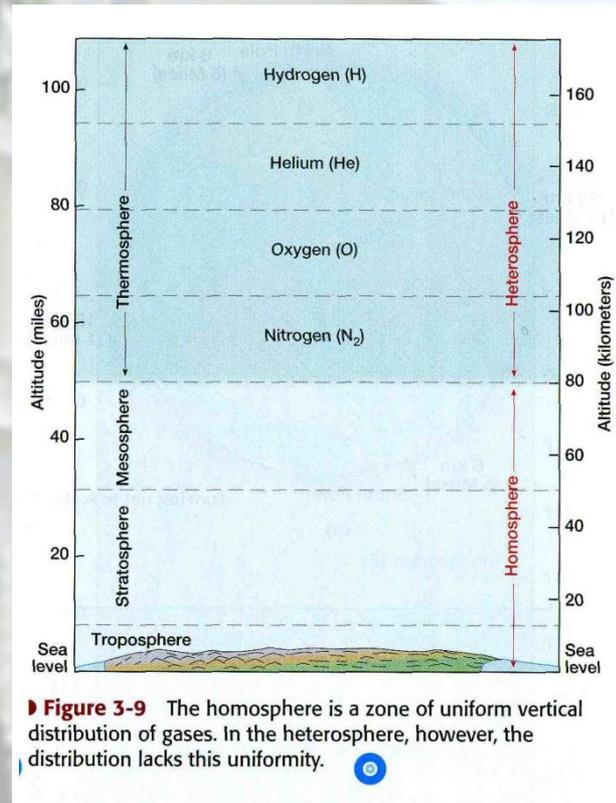
On the basis of temperature distribution

The air temperature is not constant in the atmosphere; it's changing depending on atmosphere height. There are six different spheres of varied temperature characteristics. Each of them is closed in the upper limit with so called pause layers.



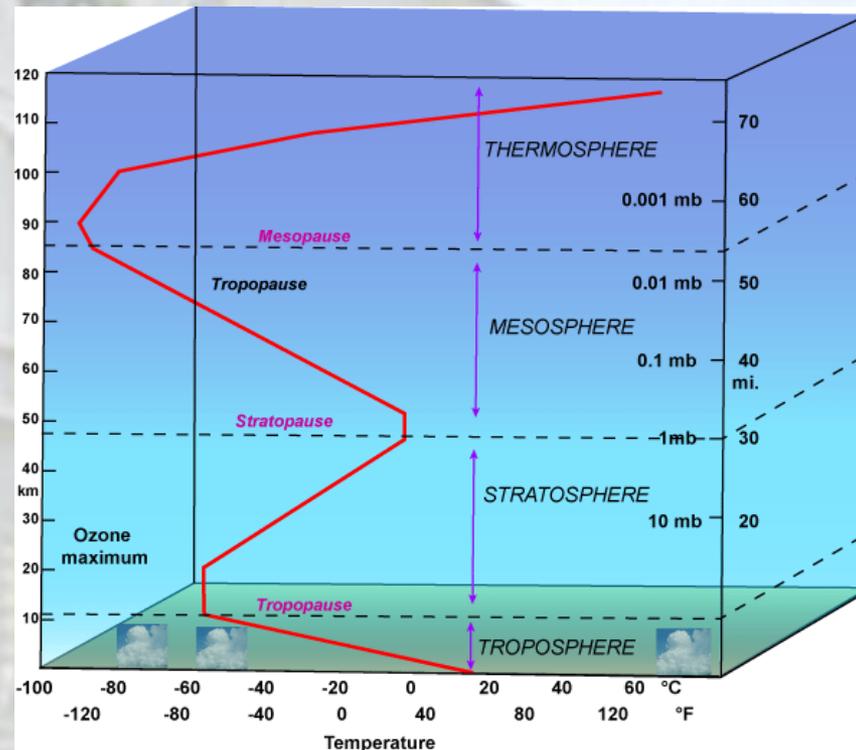
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Fig. 4 The homosphere and the heterosphere



http://www2.pvc.maricopa.edu/ssd/geog/outlines/universal_images/separate/hom_het_sphere.jpg

Fig. 5 Thermal layering of the atmosphere



www.geol.umd.edu/~jmerck/geol100/lectures/33.html



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The **troposphere** is the closest layer to the surface. Its average height is about 11km. The varied gravitation attraction results a narrow thickness above the poles (6-8km). The largest extension can be found above the Equator (16-18km). The temperature of the troposphere is declining with height. The size of cooling is expressed with lapse rate; the temperature change for a given distance ($0.65^{\circ}\text{C}/100\text{m}$). This is the vertical temperature gradient. There may also be some embedded warmer layers in the troposphere, the temperature inversions. In case of inversions the vertical mixing is resisted. In presence of inversion, pollutant accumulates close to our living place.



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The second layer is the **stratosphere** up to height of 50km. The lower half of the sphere there is an inversion, where the ozone and oxygen absorbs the UV radiation and heats the layer. (The special sub-layer, the ozonosphere is located here.)

This warm layer, the inversion inhibits the mixing processes and causes an increased residence time of particles reaching the stratosphere (volcano eruptions, results of human activities). This was observed after hydrogen bomb tests in 1950s and 1960s, when radioactive fallout was observed as long as two years following the nuclear test.





In the second half of the stratosphere the temperature is increasing with height (above 23-25km).

The stratosphere is followed by the coolest layer of the atmosphere, by the **mesosphere**. This layer is up to 85-90km. The name bears notice of „between” something. The reason of cold temperature is the lack of ozone and oxygen. The coldest temperature can be observed on the top of the layer as -93°C .

In the **thermosphere** above 90km, the temperature is growing with height. It reaches more hundred degrees centigrade.





The reasons are

- the high absorption of solar radiation
- the behavior of nitrogen and oxygen molecules
 - dissociation
 - stripping of electrons from the atoms

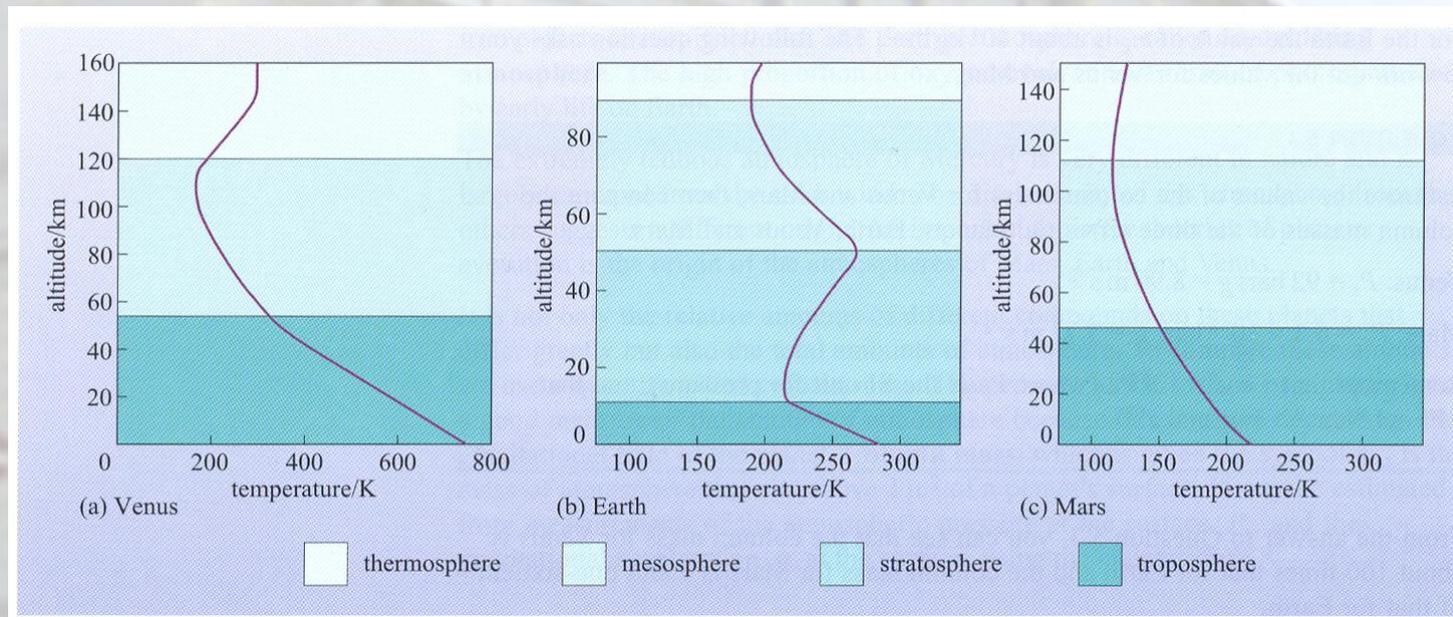
Due to these processes photo-dissociation and photo-ionization are taken place.

The external layer of the atmosphere is the **exosphere**. We do not know its final height. The knowledge regarding this sphere is limited.





Fig. 6 Let's compare the thermal layering of the neighboring planets! What is the main difference?



http://lasp.colorado.edu/~bagenal/3720/CLASS13/EVM_layers.jpg



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Optical properties of the atmosphere

The atmosphere is relatively transparent to incoming short wave radiation, that reaches the surface and reflects back to the air. A part of the energy escapes to the space serving a good basis to satellite image analysis.

The compounds of the air scatter the radiation, changing the energy balance, and produce special optical impacts. The back-scattering is one of the reasons of atmospheric energy retention change.

The pollutant modifies the optical air characteristics on a higher extent. We discuss it later on.





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Thank you for attention!



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