Tananyag fejlesztés idegen nyelven

Prevention of the atmosphere

KÖRNYEZETGAZDÁLKODÁSI AGRÁRMÉRNÖKI MSC

(MSc IN AGRO-ENVIRONMENTAL STUDIES)

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The POPs.
Emission source configuration
Timescales for traces in the air

Lecture 7

Lessons 19-21

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Lesson 19

Persistent Organic Pollutants with their protocol. Emission source configurations

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2a) Persistent Organic Pollutants (POPs)

These pollutants are stable compounds resistant to degradation. They are persistent in the environment (soil and atmosphere also)

Big family including dioxins, furans, polychlorinated biphenyls (PCBs) and organochlorine pesticides (DDT). More pesticides belong to the category. Most important sources are different productions:

- solvents
- polyvinyl chloride (PVC)
- medicines
- pesticides

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They may be classified as airborne particles rather than gaseous pollutants.

Their harm manifests through food consumption; mainly animal fat accumulates this toxic material.

Impact of POP

- Death and illness including disruption of endocrine,
- reproductive and
- immune systems,
- Neurobehavioral disorders
- Cancer

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POP Air Pollution Protocol

„The Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution on Persistent Organic Pollutants is an agreement to provide for the control and reduction of emissions of persistent organic pollutants (POPs) in order to reduce their transboundary fluxes so as to protect human health and the environment from adverse effects." It opened for signature on 24 June 1998 and entered into force later, on 23 Oct. 2003.

Twenty-seven countries and the European Union have ratified the treaty soon and a further nine have signed but not yet ratified.

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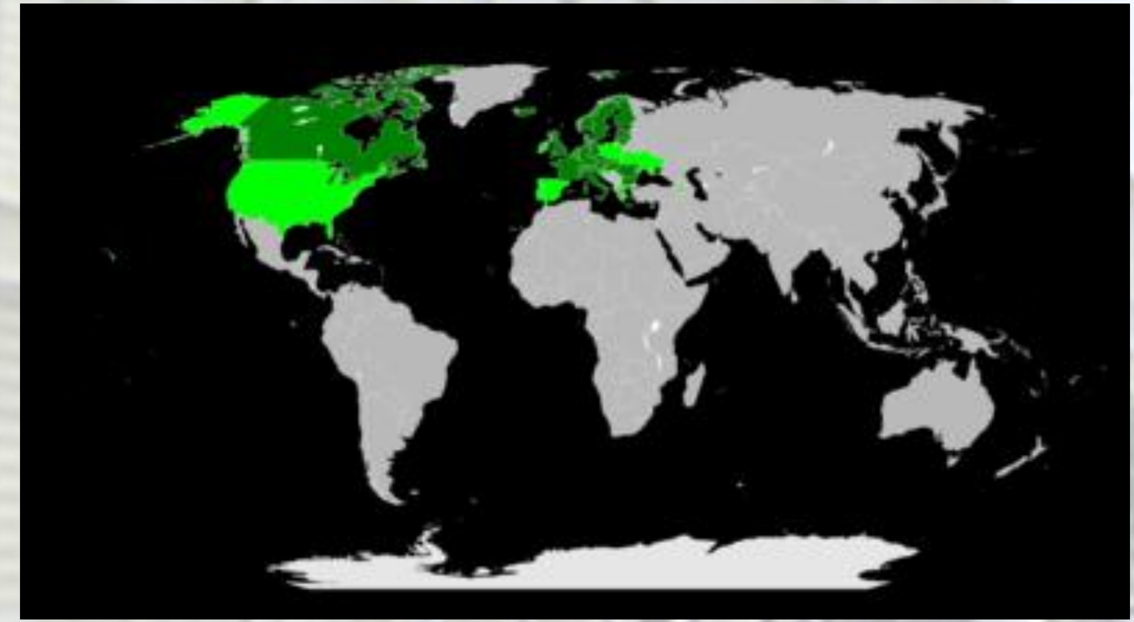
Fig. 59 Map showing Persistent Organic Pollutants signatories (green) and ratifications (dark green) as of July 2007



http://en.wikipedia.org/wiki/POP_Air_Pollution_Protocol

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United Nations Environment Programme
Production and Consumption Unit

UNEP

Global Monitoring of Persistent Organic Pollutants(POPs)

- At the request of the POPs Intergovernmental Negotiating Committee UNEP Chemicals has launched a POPs Global Monitoring Programme
- This program is intended to form a basis for the effectiveness evaluation of the Stockholm Convention

(Stockholm Convention on Persistent Organic Pollutants is an international environmental treaty that aims to eliminate or restrict the production and use of POPs.)

- Activities will include developing guidance on sampling and analysis of POPs, data treatment, communication of actual position and data assessment
- In addition the program will include an electronic discussion group on POPs monitoring issues, where existing programs and laboratories are invited to participate and share their experience on this subject.

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Source configurations

Source configurations have the complete characteristics of environmental load. The members alone are not precise characteristics: shape of the source together with its height above the ground surface and duration of given contamination.

Shape of sources

- point sources are the most dangerous sources as the pollutant concentration is the highest around them. Due to this fact we often focus on point sources. It is e.g. a chimney stack that may produce concentrated and toxic materials: both gases and particulates..

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To know the dispersion of contaminant around our living place, the point sources have of primary importance .

- Great number of cars on a busy highway release pollutants continuously. Integrating the exhaust gas of separate vehicles along a length of road results the total environmental load coming from vehicles. They are the line sources. In highways the traffic density determines the strength of this pollution.

- Diffuse or areal source is the sum of point sources; cities provide a good example for it.

In environmental load calculations, the sources are often treated separately. The power plants are separated from their surroundings (as point sources).

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On local scale, grid squares are applied to distinguish the different source releases one by one. (Globally it is impossible.)

Hemispherical or continental level assumes for example a large city as a point source on the grid map.

Source levels

Vertically there are two levels of sources

- ground level means release close to the surface
- elevated level means place above the chimney stacks

Next table contains typical source configurations with examples after Oke.

Table 7 Source configurations

Typical source configurations.

Shape	Duration	Height	Example
Point	Continuous	Elevated	Chimney stack
		Ground	Bonfire
	Instantaneous	Elevated	Shell burst
		Ground	Explosion
Line	Continuous	Ground	Busy highway
	Instantaneous	Elevated	Crop spray; Aircraft exhaust
Area	Continuous	Elevated	City; forest or field fire

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Lesson 20

Estimation of environmental loads. Scaling of the atmospheric processes timescales included

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The estimation of emission of different sources is difficult mainly in biogenic processes. Concerning the total particulate mass release the biogenic emission is dominant. Parametrization is applied to estimate the probably values of different loads (see Table 8).

In Northern hemisphere the load of fossil fuel combustion by human activity is dominant. The biomass burning is told to be well balanced between the two hemispheres.

The uncertainty of sea salt estimation is extremely high. The Table sums the emission of the two spheres for 2000 after IPCC Third Assessment Report and Sportisse. The range of uncertainties is indicated inside brackets of estimates.

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Table 8 Estimation of aerosol emissions (in Tg $year^{-1}$)

Type	total		North	South
Sea salt	3344	[1000, 6000]	43%	57%
diameter < 1 μm	54	[18, 100]		
diameter in [1, 16] μm	3290	[1000, 6000]		
Mineral aerosol (dust)	2150	[1000, 3000]	84%	16%
diameter < 1 μm	110			
diameter < [1, 2] μm	290			
diameter in [2, 20] μm	1750			
Organic aerosol				
biomass burning	54	[45, 80]	50%	50%
fossil fuel combustion	28	[10, 30]	98%	2%
biogenic	56	[0, 90]	98%	2%
Elemental carbon	12.3			
biomass burning	5.7	[5, 9]	50%	50%
fossil fuel combustion	6.6	[6, 8]	98%	2%
Industrial emissions	100	[40, 130]		

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Timescales in environmental pollution and their impacts

Comparison of atmospheric transport to atmospheric residence time determines the impact of the given contaminant. The two groups of pollutant, primary and secondary one depend on this ratio.

When the magnitude of the above two is the same e.g. on continental scale, than the impact will be acted at least on continental level (over Europe, Asia etc.)

When the magnitude of residence time is close to the exchange time from troposphere to stratosphere, than the contaminant will reach the upper atmospheric layer, the stratosphere.

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Scales of the atmosphere

Our starting point is the atmosphere’s space and time scales, where the contamination comes true.

Space scale is expressed in size of the atmospheric phenomenon. The time scale contains the typical lifetime of air compounds. These two scales are not independent on each other, see Fig. 54. It is important to note, that these features are the members of the same substance, of the atmosphere. To study and characterize them we try to distinct the elements of the same continuum.

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In majority of works dealing with spatial categorization of the atmosphere the following schemes are used:

- Micro- scale 10^{-2} to 10^{3} m
- local- scale 10^{2} to 5×10^{4} m
- Meso- scale 10^{4} to 2×10^{5} m
- Macro- scale 10^{5} to 10^{8} m

As Fig. 54 shows from the eddies (small-scale turbulence) to the jet streams (wind encircling the whole planet) the spectra of atmospheric phenomenons is wide.

The smallest limit is of the order of 10^{-2} m.

Pollution may cover all scales..

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- In vertical air stratification the turbulence , one of the most important air motions in mixing the pollutant in the air, persists in the boundary layer. The height of this layer is not constant with time. By day the heated air moves upward and the thermal convection height is about 1 to 2 km. By night the downward transfer of heat is formed that suppress mixing and the layer depth is only about 100 m. This daily variation is the result of sun activity. It may be changed by large weather pattern (wind origin) not belonging to the surface tied events.
- The scale limits of boundary phenomenas are 1 and 50 km vertically and horizontally, respectively and 1 day temporally.

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Fig. 60 Scales in the atmosphere (after Oke)

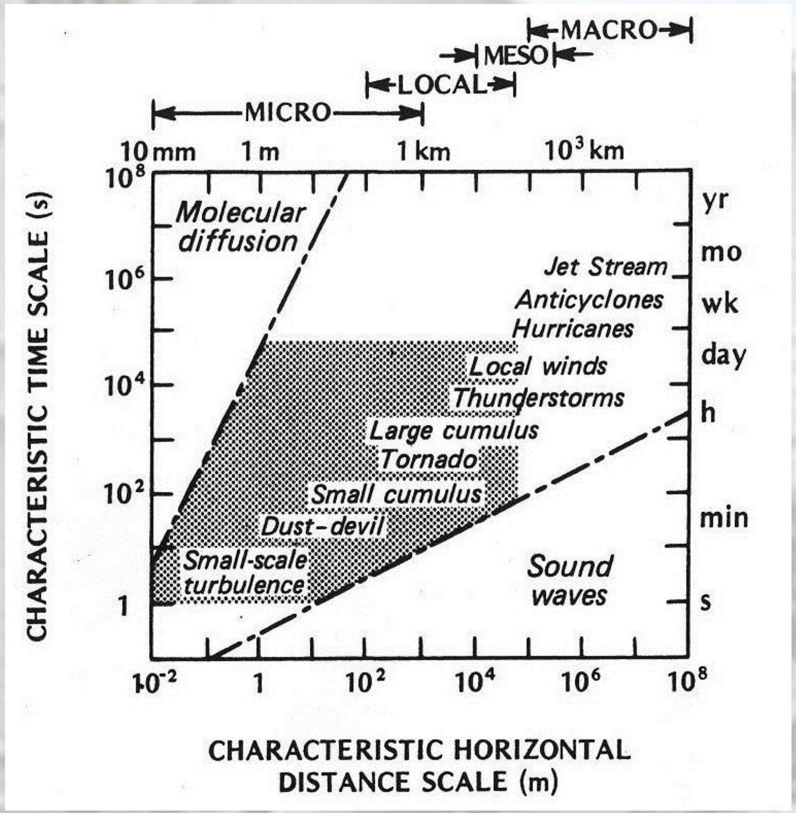

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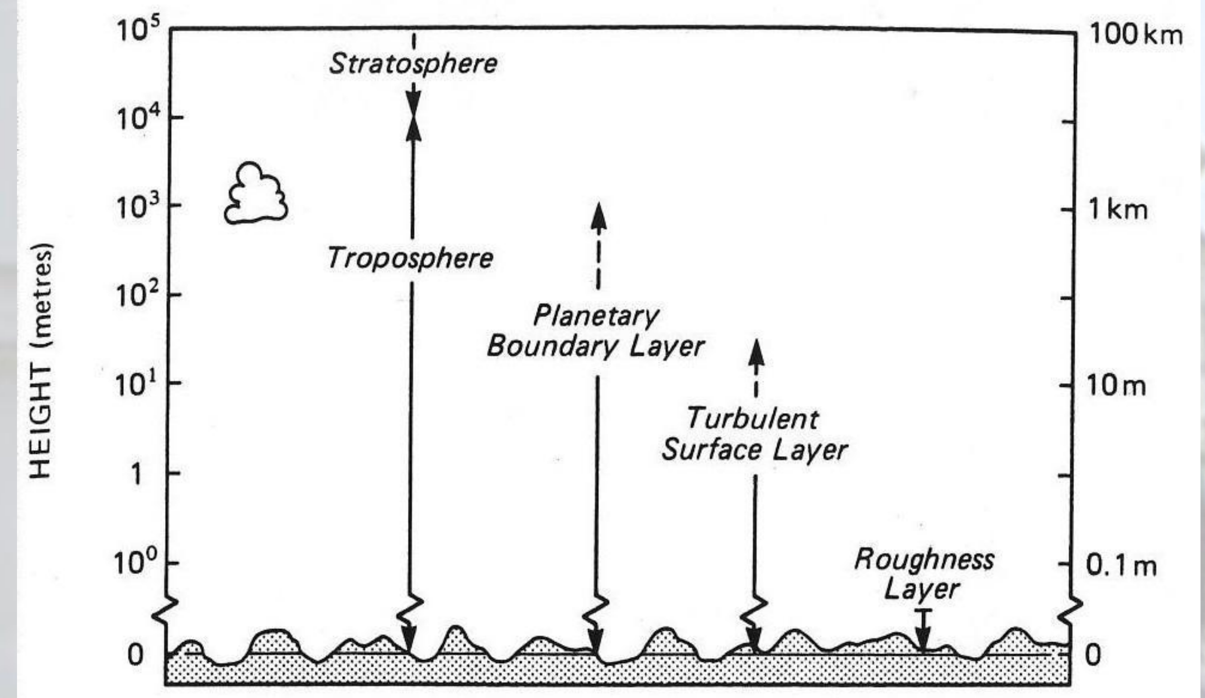
Fig. 61 Vertical air layers (after Oke)



The vertical structure of the atmosphere.

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Timescales for pollutants

The timescales of tracers are used to determine the exchanges between the atmospheric reservoirs (troposphere, stratosphere and hemisphere)

<u>Horizontal transport</u>

The horizontal transport means carrying materials by the winds. The average wind velocities (U) for the zonal transport are (West/East) $10 ms^{-1}$.

For the meridional wind velocity (South/North), we assume less mean wind speeds; at about 1 to $2 ms^{-1}$.

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The timescales (*τ*) for the transport of a trace element of mid-latitudes origin (in Europe or in North-America), for L characteristic spatial scale:

$$\tau = L/U.$$

After calculations, the following horizontal timescales will yield:

- a few days for continental transport
- from one to two weeks for transcontinental transport (transatlantic, transpacific)
- from one to two months for hemispheric mixing

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(both in the Northern Hemisphere or in the Southern Hemisphere)

- from one to two months for transport to the Equatorial region or to the polar regions

The characteristic timescale for the interhemispheric exchange is about 1 year.

Horizontally the process of mixing occurs

- through the seasonal meridional motions of the ITCZ,

- or through local breaks of this convergence zone

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Lesson 21

Vertical transport in the air – the turbulent diffusion. Residence time in the atmosphere – groups of traces

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Vertical transport in the air

Vertical transport by winds is much weaker than the horizontal one.

The less effective element of winds is the molecular diffusion; it can be neglected

(with only one exception – the air close to the surface layer).

The vertical motion in the atmosphere is governed by the buoyancy effect highly correlated with turbulence.

Let be the spatial scale *L (now* in vertical direction*),* than the characteristic timescale (τ) can be get:

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$$\tau = L^2/Kz$$

where the Kz is the turbulent diffusion coefficient

($10\text{-}20\ m^2\ s^{-1}$)

Calculating the exact values the timescale for transport in the atmospheric boundary layer varies from a few

hours to one day. The length of the period is dependent on the atmospheric stability (air temperature – lapse rates), and defines the magnitude of Kz.

The characteristic timescale for vertical tropospheric mixing is about one month (in the troposphere only).

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The vertical timescales for transport between the different spheres:

- Atmospheric boundary layer: 1 hour–1 day
- Free troposphere (5000 m): 1 week
- Troposphere: 1 month
- Exchange from troposphere to stratosphere from 5 to 10 years
- Exchange from stratosphere to troposphere from 1 to 2 years

Next table sums the two types of timescales.

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Table 9 Timescales for the transport in the air (Sportisse)

Transport	Characteristic timescale
Continental	1 week
Transcontinental	2 weeks
Hemispheric	1 month
Interhemispheric	1 year
Atmospheric boundary layer	1 hour–1 day
Free troposphere ($\simeq 5000\,m$)	1 week
Troposphere	1 month
Exchange from troposphere to stratosphere	from 5 to 10 years
Exchange from stratosphere to troposphere	from 1 to 2 years

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Atmospheric residence time (traces)

The *loss processes in the atmosphere determine the* atmospheric residence time *that affect the life of the traces* such as:

- dry deposition at the Earth's surface included sedimentation
- Wet deposition by precipitation
- chemical or photochemical reactions
- radioactive decay (for radionucleis)

The exchange of traces between the atmosphere and the space can be neglected (closed system!)

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- Using the first-order kinetic laws and assuming linear processes in the atmosphere, that is widely applied in approximation for chemical kinetics, the time evolution of the mass concentration of species x, *ρx, is governed* by:

$$\frac{d\rho x}{dt} = -k \ \rho x$$

Where *t* stands for time and *k* is the kinetic rate. The timescale (τ) is the reciprocal of *k*.

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The time evolution is:

$$\frac{d\rho x}{dt} = -(\Sigma_i k_i\ )\rho x$$

Than the global characteristic timescale is given by

$$\frac{1}{\tau} = \Sigma_i k_i\ )\frac{1}{\tau_i}$$

Let it be a trace species x, that emits a mass rate *Ex.*
The global mass budget for this x element is:

$$\frac{dmx}{dt} = Ex - \frac{mx}{\tau x}$$

The *mx holds the meaning of the total species mass.*
At equilibrium,

$$mx = \tau x \, Ex$$

Having these knowledge the characterization of the most important trace elements can be fulfiled.
- CFCs are stable gases, having a lifetime up to tens of years. Their impact is always global and stratospheric

- mercury has a lifetime ranging from 1 to 2 years; the impact is global (but only tropospheric)
- tropospheric ozone has a lifetime of a few days: the scale in photochemistry is at least regional, or transcontinental
- the timescale of SO_2 is about 2 days (change to sulfuric acid, H_2SO_4): impact of SO_2 emissions is local.

The lifetime of H_2SO_4 governed by wet deposition is about 5 days: the impact scale of acid rains is regional

- the residence time of the aerosols (particulates) is about 9 to10 days

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- persistent organic pollutants (POPs) have a long residence time with the minimum value of a few months.

The POPs are able to accumulate in different ecosystems by reaching the surface through wet or dry deposition.

They are considered as the future atmospheric and soil contaminations.

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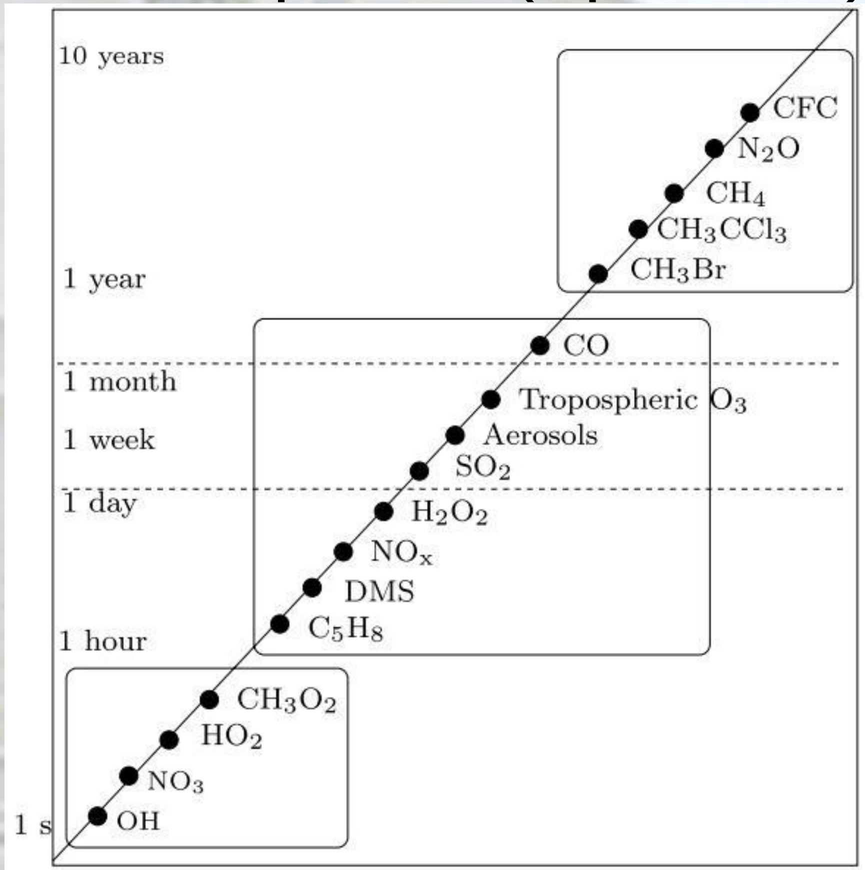
Fig. 62 Residence time of the most important air species (Sportisse)



Excercise

Calculate the atmospheric residence time of methane in case of equilibrium! The total yearly emission of the gas is assumed to be 598 Tg (natural and antropogen sources together).The actual concentration of methane is 1.7 ppmv.

- The total mass of the methane gas will be:

$$1.7 \times 10^{-6} \times (M_{CH4}/M_{air})/m_{atm}$$

Where M is the related mole number

The mass of the air, m_{atm} is 535 Tg; see earlier!

Than the residence time will be: 4700/535 ~ **8 years**

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Thank you for attention!

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