Introduction to air pollution

Jesús Miguel Santamaría

Universidad de Navarra

Atmosphere of Earth

- Radius: 6,400 km
- 97% of air is in lowest 30 km
- So the atmospheric depth is: 30/6400 x 100 = 0.5% of Earth's radius
- The atmosphere is a thin envelope surrounding the Earth

Atmosphere of Earth

30 km

97% of atmospheric mass lies within 30 km of the Earth

5 km — 50% of mass

2 km — 50% of water

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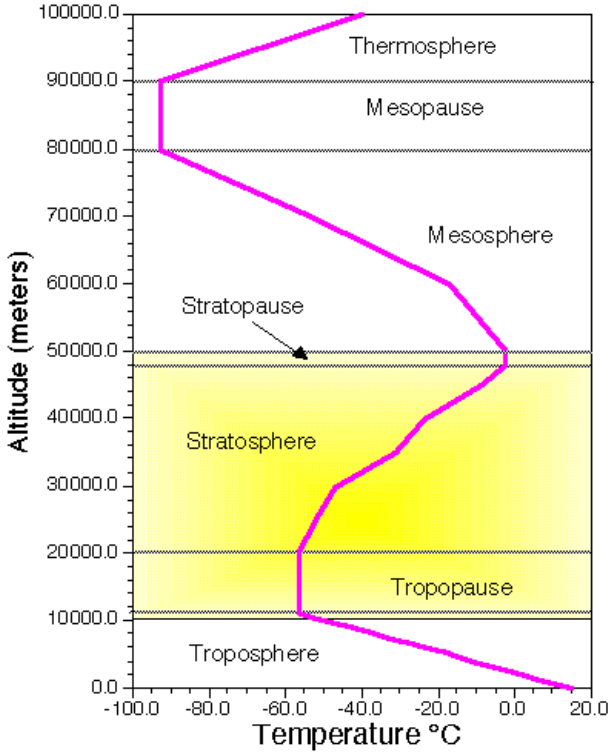
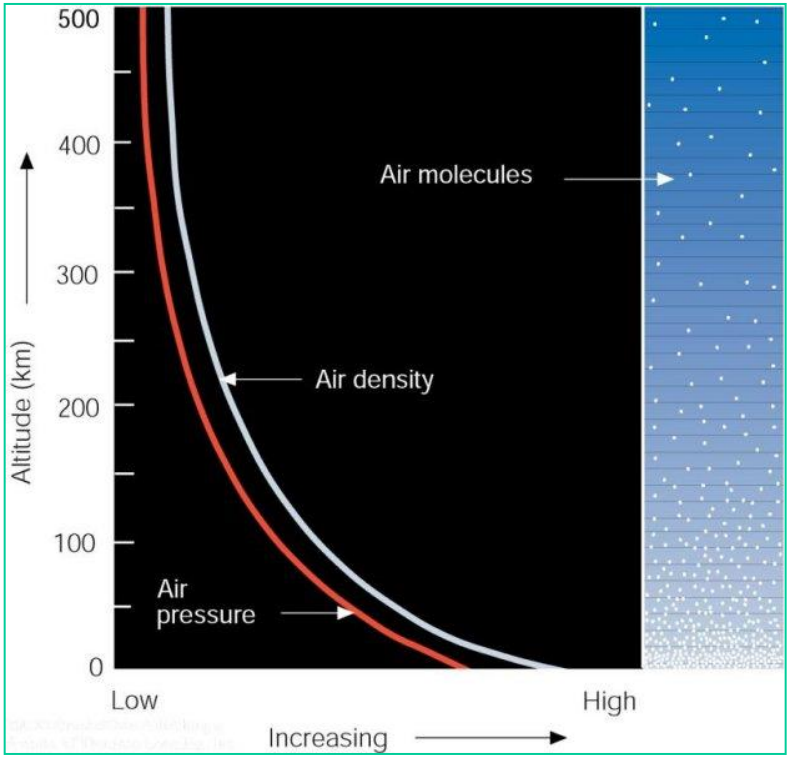
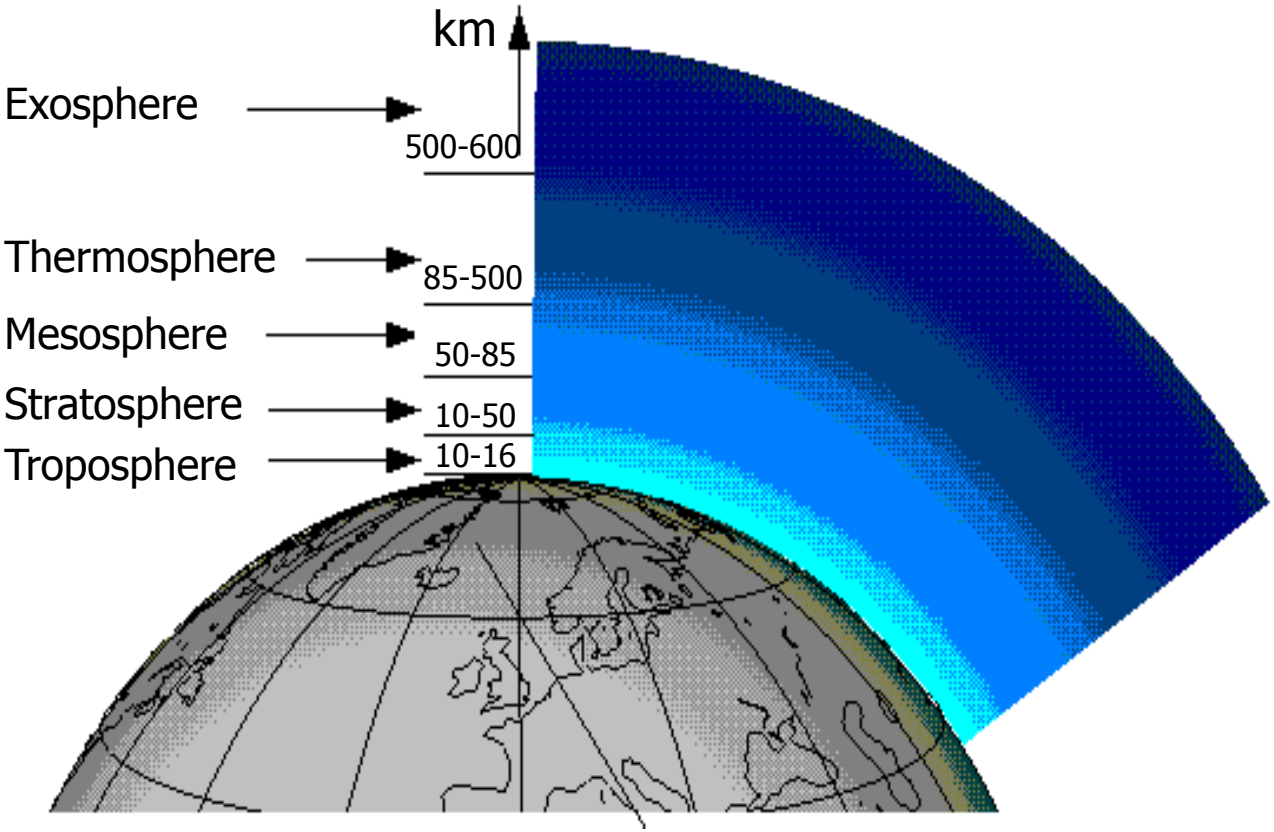
Atmosphere of Earth

The atmosphere is stratified in layers on the basis of temperature/density relationships





Thermal structure of atmosphere



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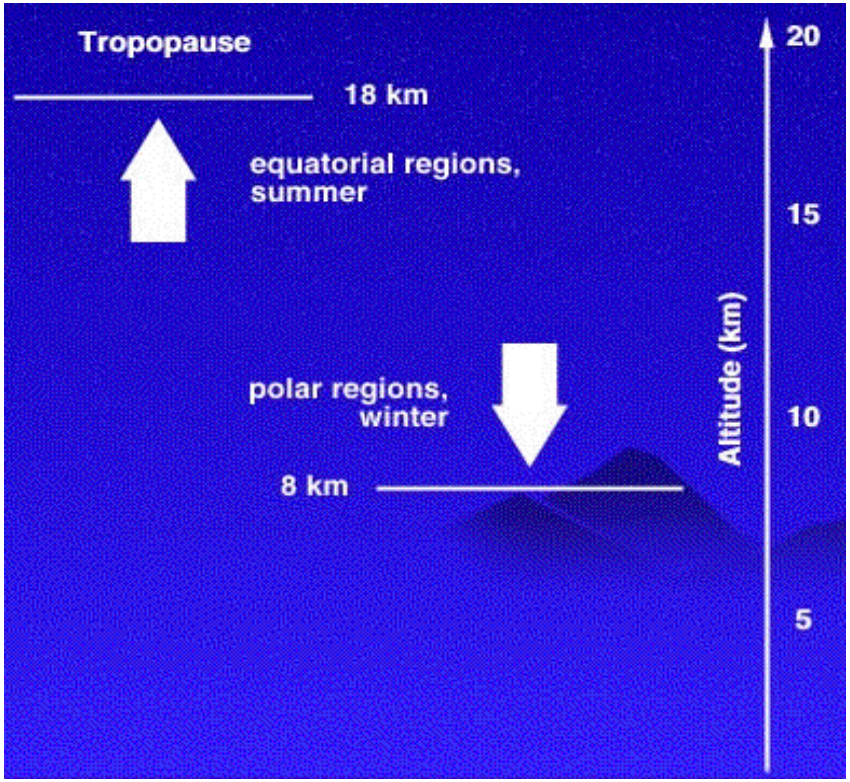
Thermal structure of atmosphere

- **Troposphere**

- ✓ Lowest portion of Earth's atmosphere
- ✓ Average depth: surface to 8-20 km
- ✓ Uniform chemical composition
- ✓ It includes the boundary layer (≈ 1 km)
- ✓ Tropopause: border between the troposphere and stratosphere
- ✓ Weather occurs in the troposphere
- ✓ Pollutants are emitted and dispersed
- ✓ It is the densest layer of the atmosphere



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Thermal structure of atmosphere

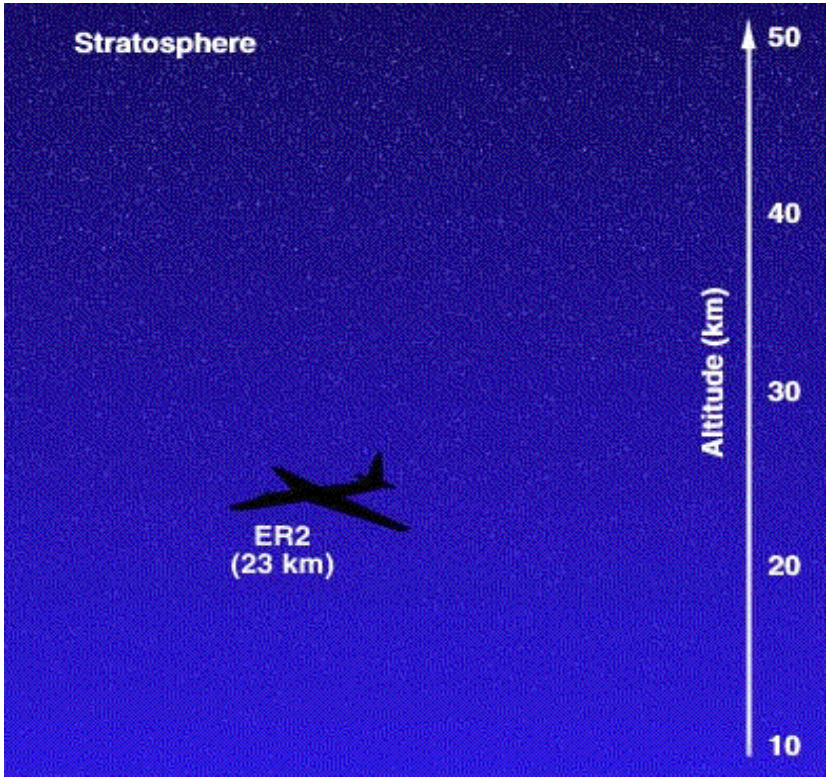
- **Stratosphere**

✓ In the lower stratosphere temperature remains constant

✓ Temperature rises with altitude until reaching - 2ºC (absorption UV)

✓ Advantages for long-distance flights

✓ Very stable atmospheric conditions



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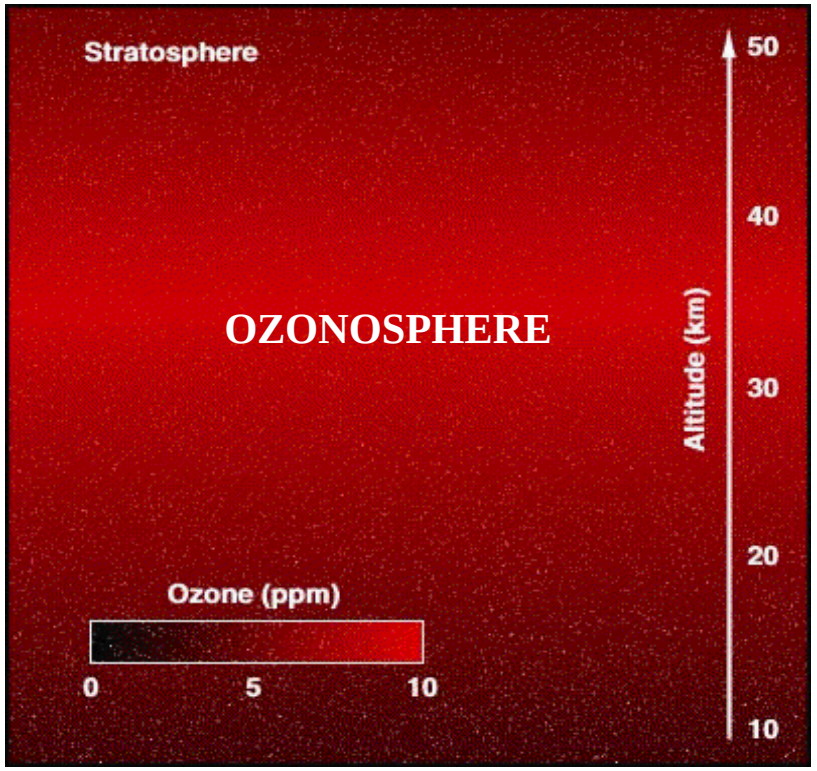
Thermal structure of atmosphere

- **Stratosphere**

✓ 90% of atmosphere's ozone occurs in the stratosphere

✓ Peak ozone concentrations occur from 15 to 20 km (10 ppm)

✓ The ozone layer blocks UV radiation (< 290 nm)



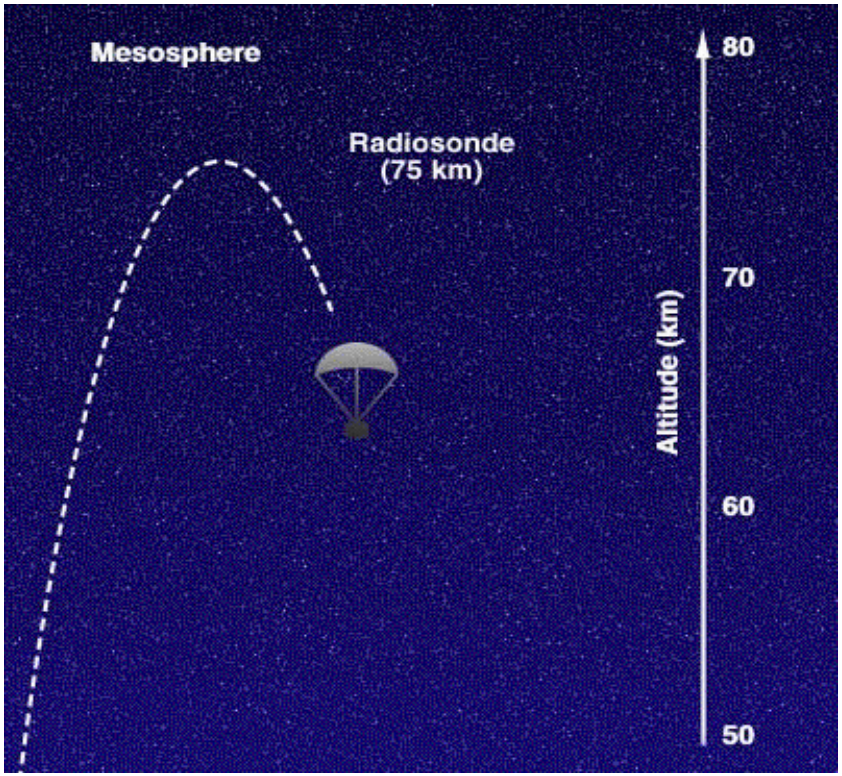
Thermal structure of atmosphere

- **Mesosphere**

✓ Temperature decreases with altitude

✓ Mesopause is the coldest part of Earth's atmosphere

✓ Mesosphere lies above the maximum altitude for aircraft



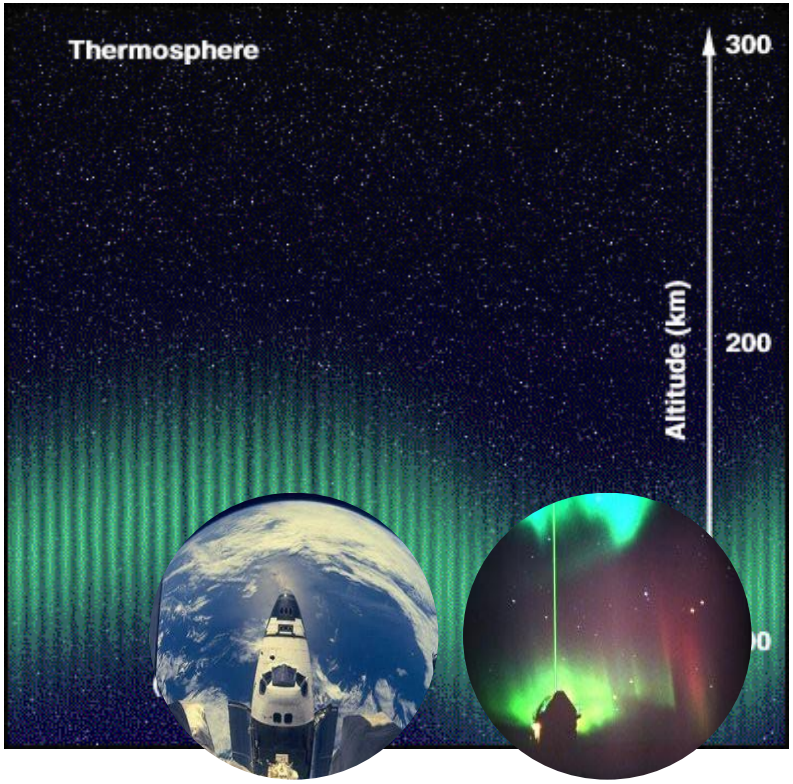
Thermal structure of atmosphere

- **Thermosphere**

✓ Within this layer UV radiation causes ionization

✓ Temperatures can rise to 2,000ºC

✓ The auroras occur in the thermosphere (charged particles collide with atoms and molecules at high altitudes, emitting photons)



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Thermal structure of atmosphere

- **Thermosphere**

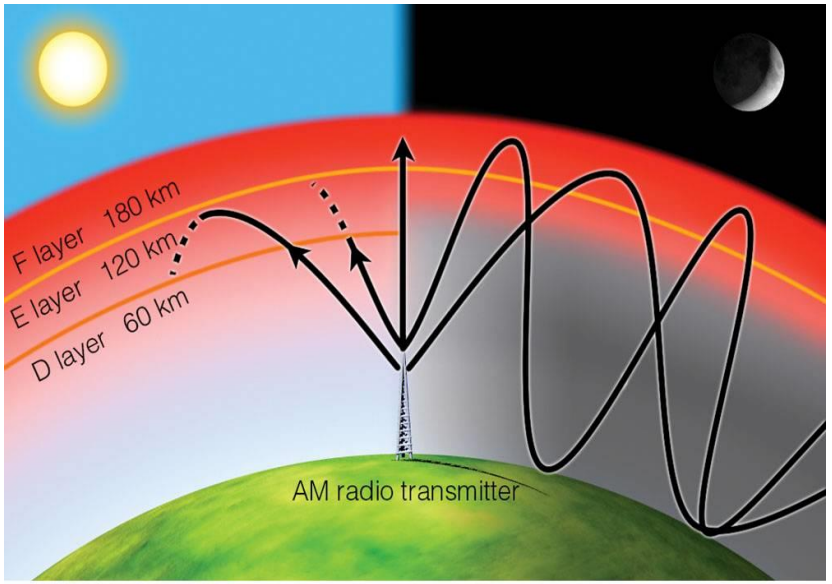
Electrical structure of atmosphere

- **Neutrosphere**

✓ Lower part of the atmosphere
✓ Particles are not ionised (0-80 km)

- **Ionosphere**

✓ From 70-80 to 200-300 km
✓ It is formed by ionization of N_2 & O_2
✓ Propagation of radio waves
✓ D layer disappears at night
✓ F layer is the main region of interest to radio communications



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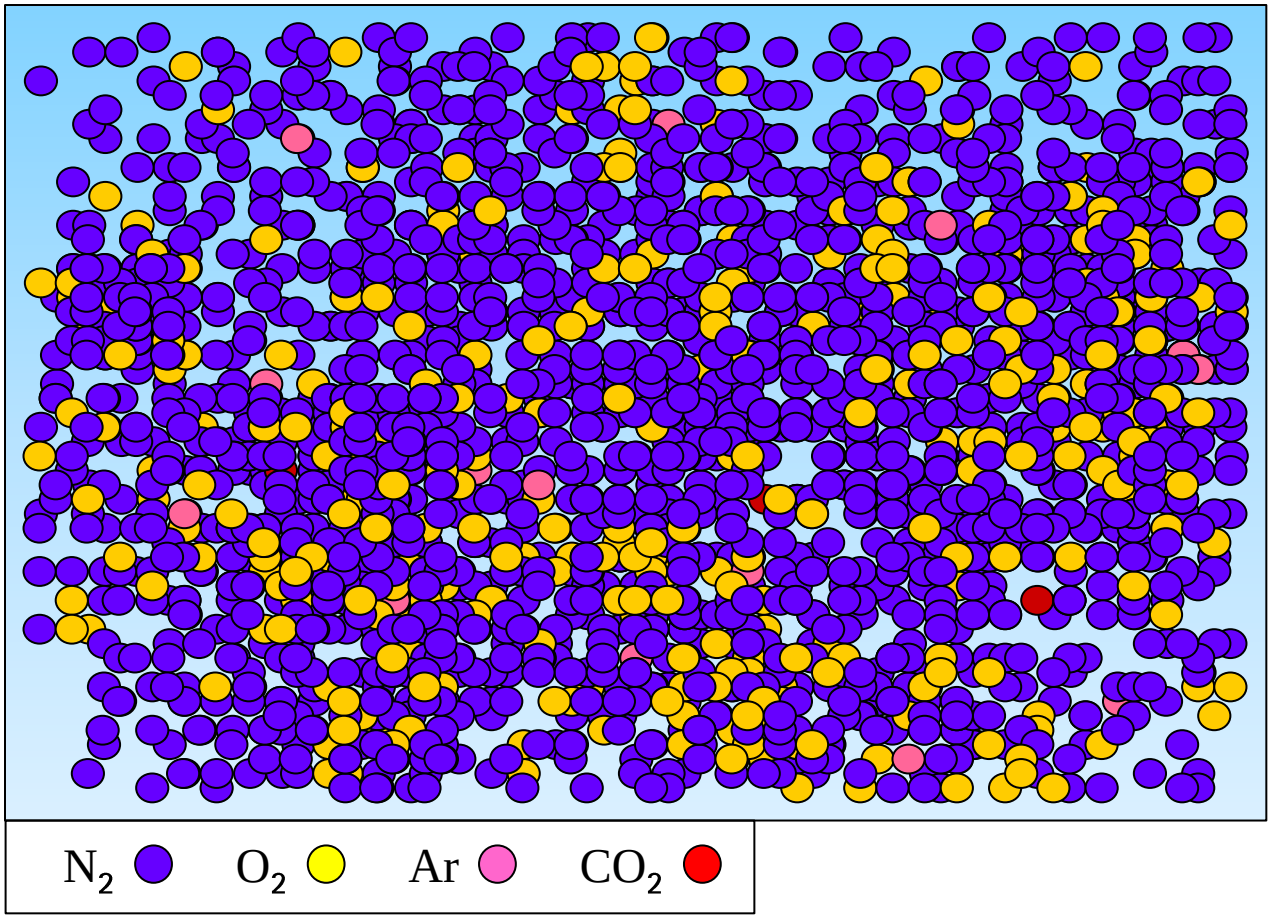
Composition of the atmosphere



Major constituents
- Nitrogen: 78.08%
- Oxygen: 20.95%

Minor components
- Argon: 0.93%
- CO_2: 0.04 %

Trace gases
- Neon: 0.0018%
- Helium: 0.0005%
- Kripton: 0.0001%
- Xenon: 0.000009%

Compound	Concentration	Residence time
N_2	78.084 %	$1{,}6\ 10^7$ years
O_2	20.946 %	5000 years
Ar	0.934 %	10^2 years
CO_2	407 ppm	< 4 years
Ne	18 ppm	
He	5.2 ppm	
CH_4	1.72 ppm	6 years
Kr	0.001 %	
CO	0.12 ppm	2 months
H_2	0.58 ppm	4 years
N_2O	0.311 ppm	20 years
Xe	0.087 ppm	
H_2O	variable	10 days
O_3	10^{-2}-10^{-1} ppm	
NH_3	10^{-4}-10^{-3} ppm	10 days
SO_2	10^{-5}-10^{-4} ppm	10 days

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Air pollution

Is the introduction of particulates, biological molecules, or other harmful materials into the Earth's atmosphere, possibly causing disease, death to humans, damage to other living organisms such as food crops, or the natural or built environment

Pollutants

Substances, artificial or natural, with capability to remain airborne, which are added in sufficient to produce measurable effects on man or other animal, vegetation or materials

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Principal air pollutants

- Carbon monoxide (CO)
- Carbon dioxide (CO_2)
- Methane (CH_4)
- Volatile organic compounds (VOC)
- Ammonia (NH_3)
- Nitrogen oxides: NO_x (NO_2 + NO)
- Tropospheric ozone (O_3)
- Sulphur compounds
- Halogenated compounds (CFC)
- Particulate matter

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Scale and residence time

Predicting air quality requires examining information for several different spatial and time scales

- **Global**

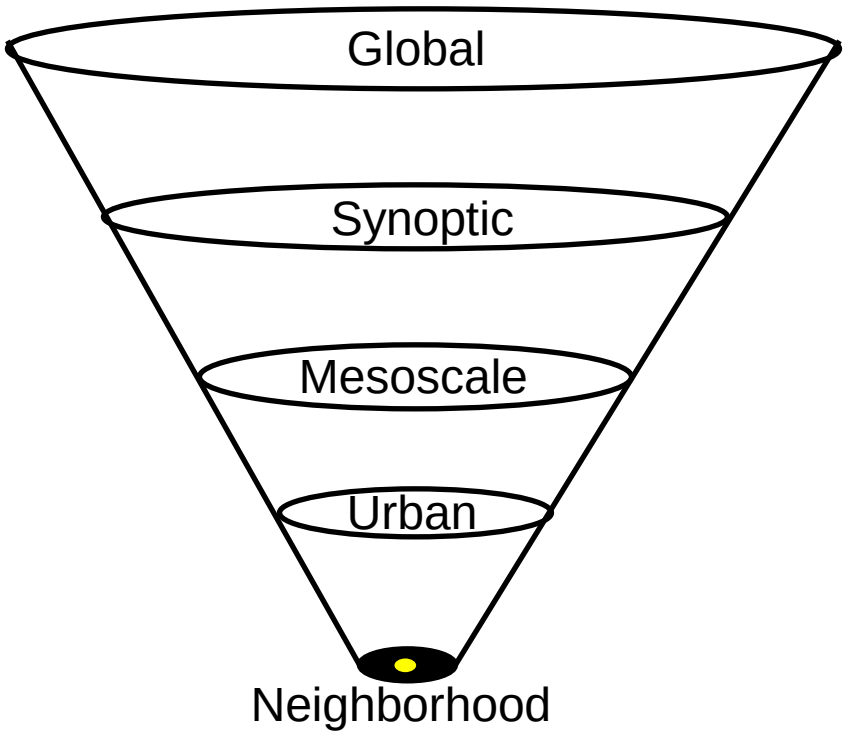
  Space: 4,000 km – 20,000 km
  Time: 1 - 2 weeks
- **Synoptic**

  Space: 400 km – 4,000 km
  Time: 1 day – 1 week
- **Mesoscale**

  Space: 10 km – 400 km
  Time: 1 hr – 1 day
- **Urban**

  Space: 5 km - 50 km
  Time: 1 hr - 4 hr
- **Neighborhood**

  Space: 500 m - 5 km
  Time: 1 min – 1 hr



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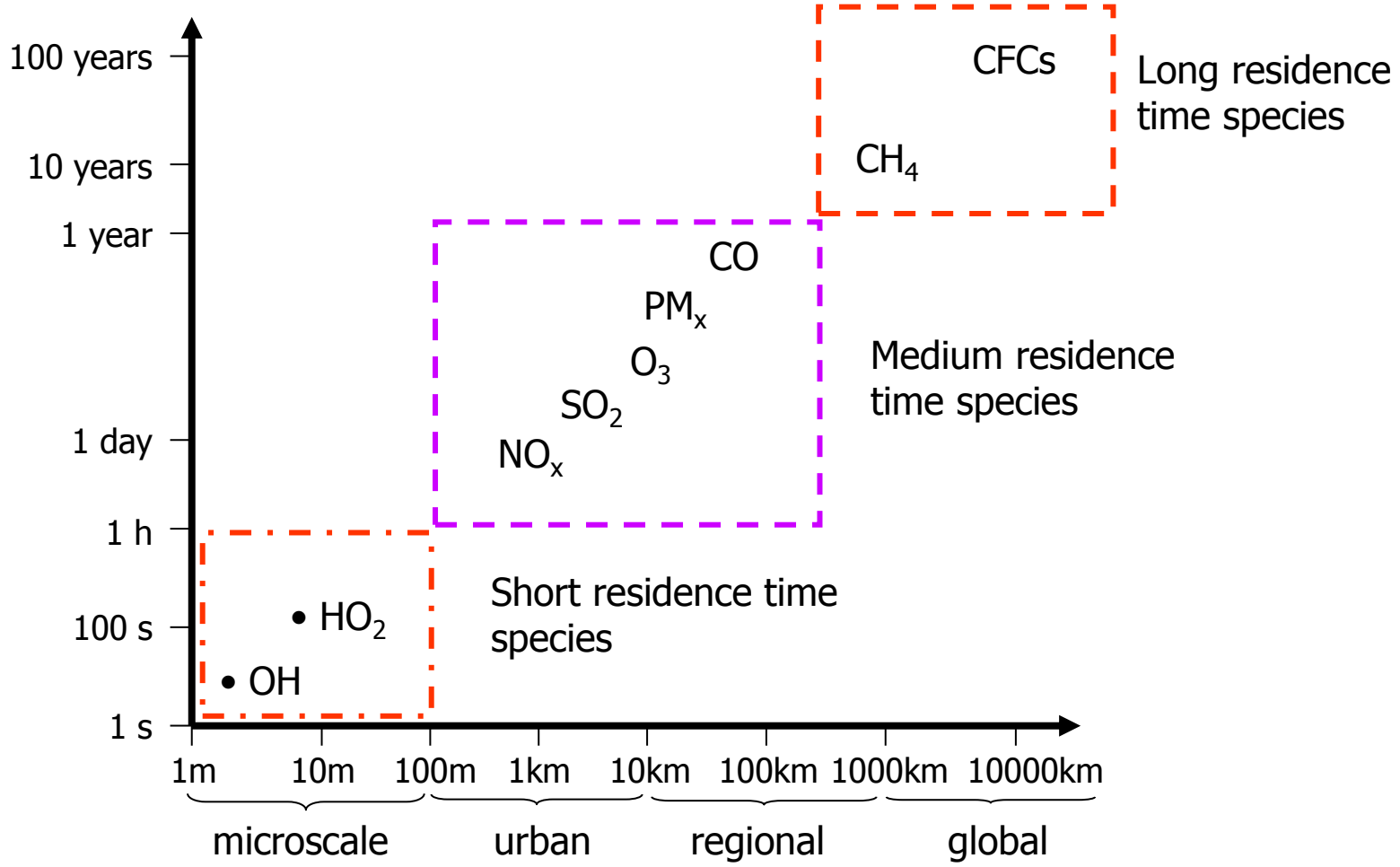
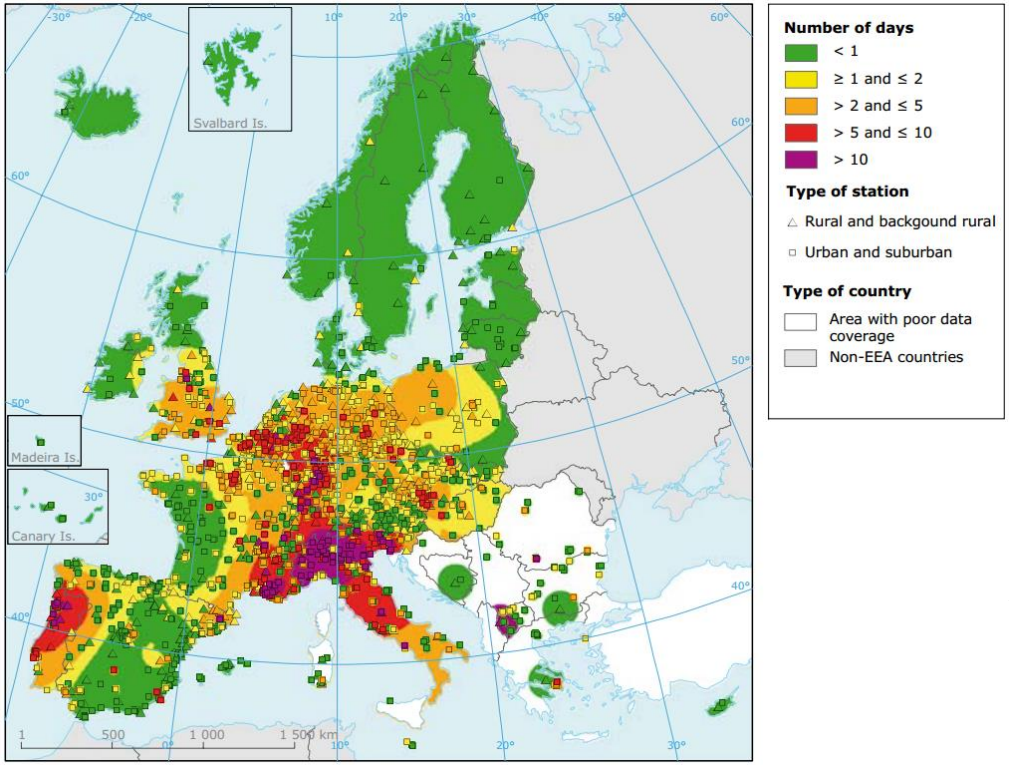
Scale and residence time

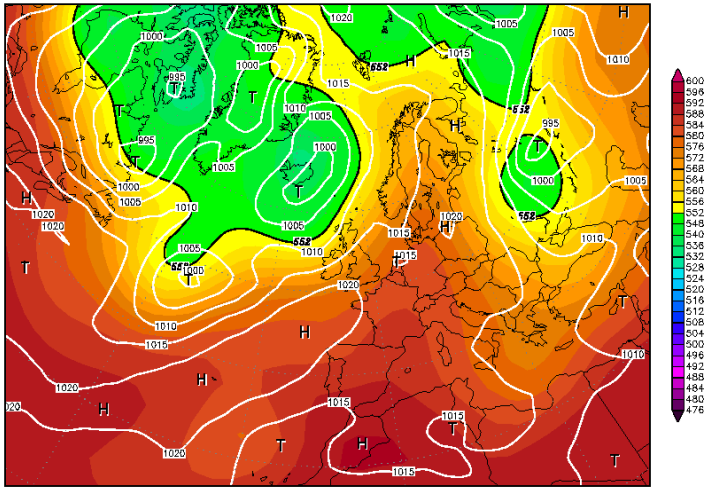


Air pollution episode

A period of abnormally high concentration of air pollutants, often due to low winds and temperature inversion, that can cause illness and death

Number of days of O_3 exceedance





Areas of high pressure (anticyclonic situation)

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Example of air pollution episodes

- 1930 Meuse Valley
- 1939 Saint Louis
- 1948 Donora
- 1952 London
- 1984 Bhopal
- 1986 Chernobil
- 1991 Kuwait
- 1997 Indonesian forest fires
- 2005 Malaysian Haze
- 2006 Southeast Asian Haze
- 2011 Fukushima
- 2016 Seseña