AIR QUALITY-

WHY WE SHOULD CARE OF IT

Jan Hovorka

Air quality laboratory,
Institute for Environmental Studies,
Faculty of Science, Charles University
Czech Republic

jan.hovorka@natur.cuni.cz

Why do we breath?

to avoid suffocation

not to quench “burning“

cell oxidation

secure enough input O_2

	inhale	exhale	difference
• oxygen O_2	20.9 %	15.3%	~ ¼ (27%)
• carbon dioxide CO_2	0.04%	4.2%	~100 x
• water vapor H_2O	0.75%	6.2%	~ 10 x
• nitrogen N_2	78.4 %	74.3%	~ $^1/_{20}$ (5%)

How much air do we breath?

adult ~10 l /min → ~15m^3 /day

$1m^3$ of air weights:

A: 1200 g

B: 120 g

C: 12 g

D: 1.2 g

~ 18kg AIR

compare to food mass!

POLLUTANTS +

78 % N_2

21 % O_2

0.04% CO_2

0.75% H_20

Frequent AIR POLLUTANTS ?

OZONE O_3

secondary pollutant

24h health limit:

$120 \mu g m^{-3}$

AEROSOL (PM)

- omnipresent atmospheric component
- colloid, suspension of solid x liquid particles

size range

1nm – 100 μm

Single aerosol particle is invisible to naked eye

but aerosol clusters are well-known macro-objects

clouds, fog, mist, haze, dust, smoke, fog

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MAN MADE AEROSOL

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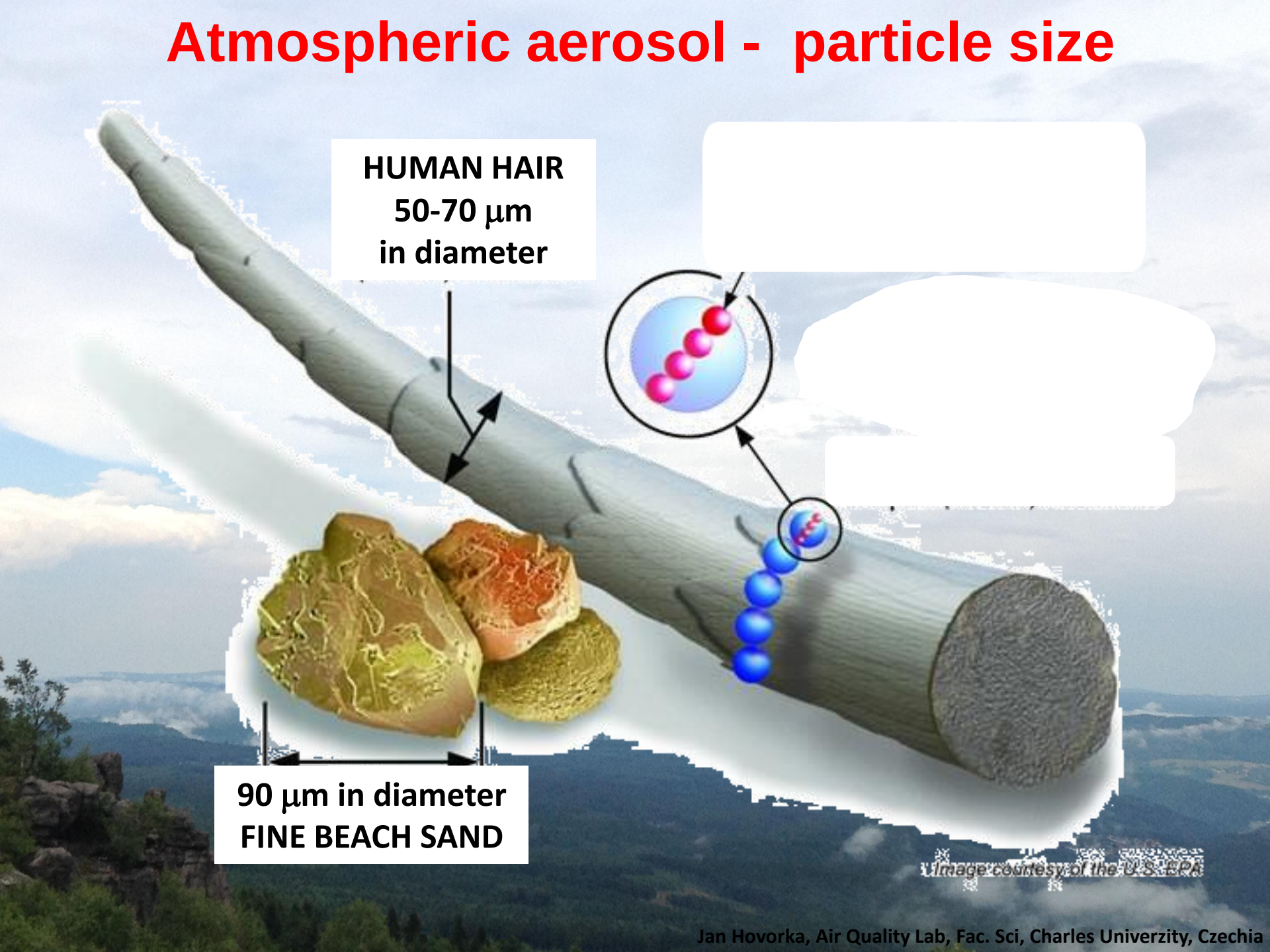
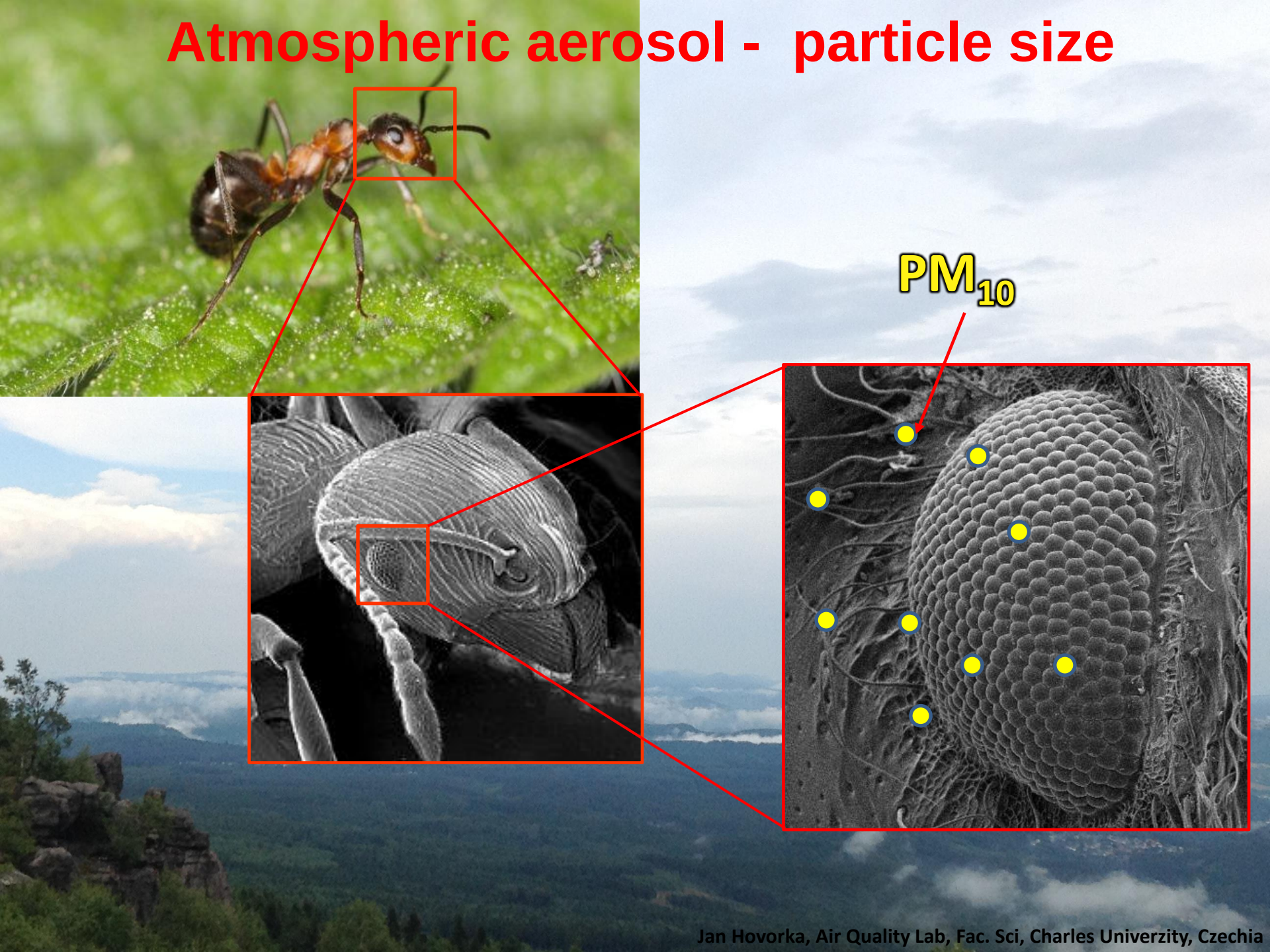
Atmospheric aerosol - particle size



Atmospheric aerosol - particle size



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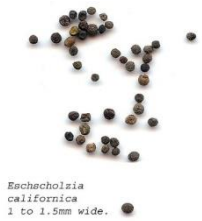
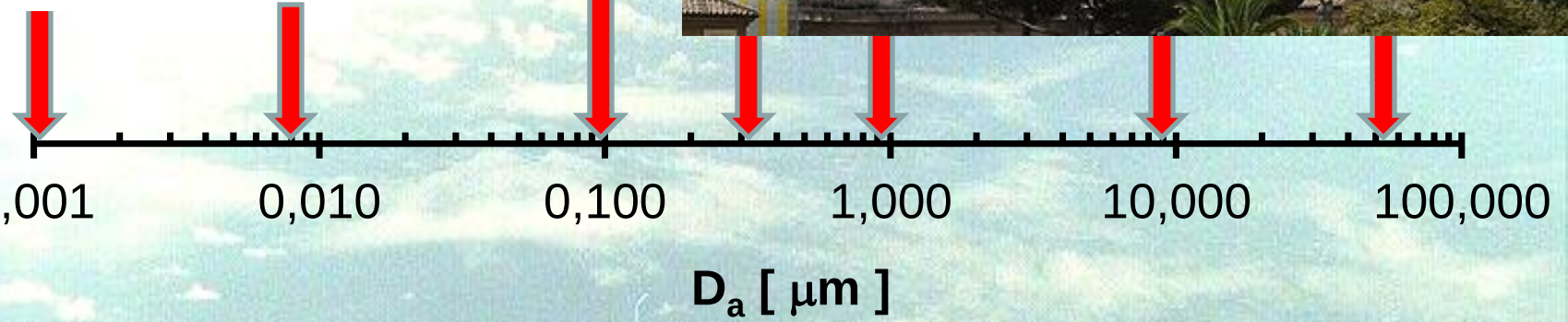
Atmospheric aerosol - relative particle size





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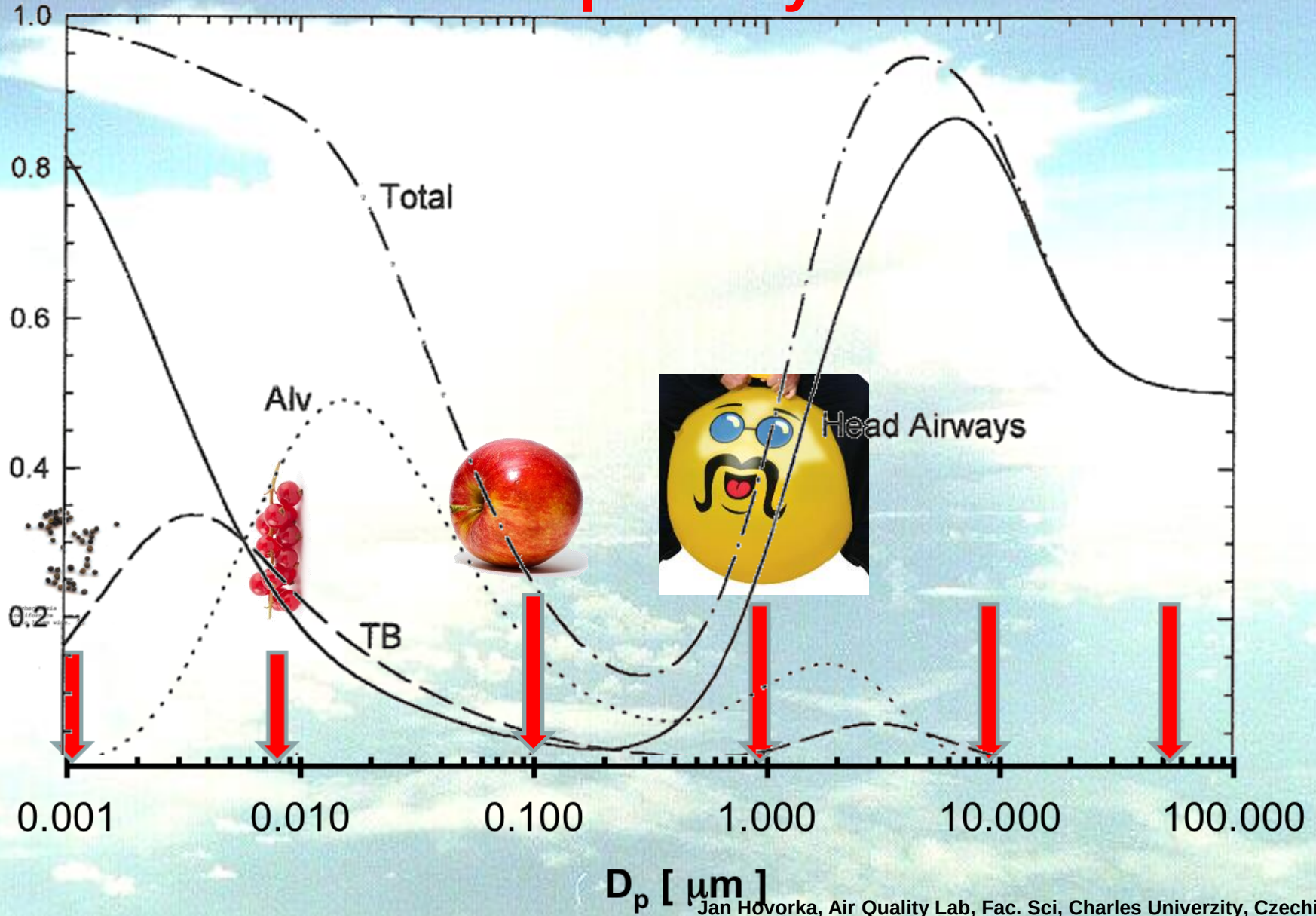
Atmospheric aerosol - penetration into human respiratory tract



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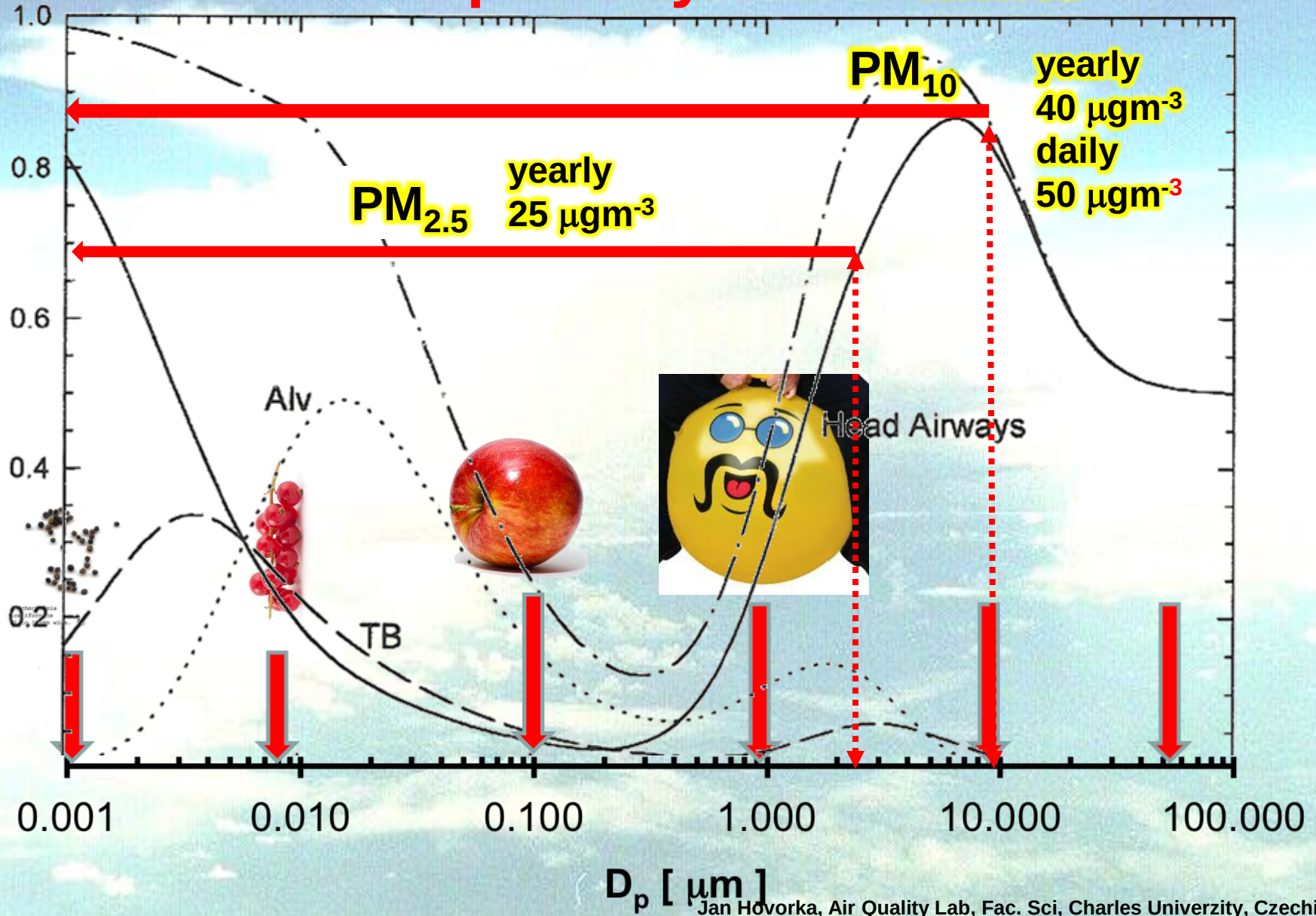
Atmospheric aerosol - penetration into human respiratory tract - limits



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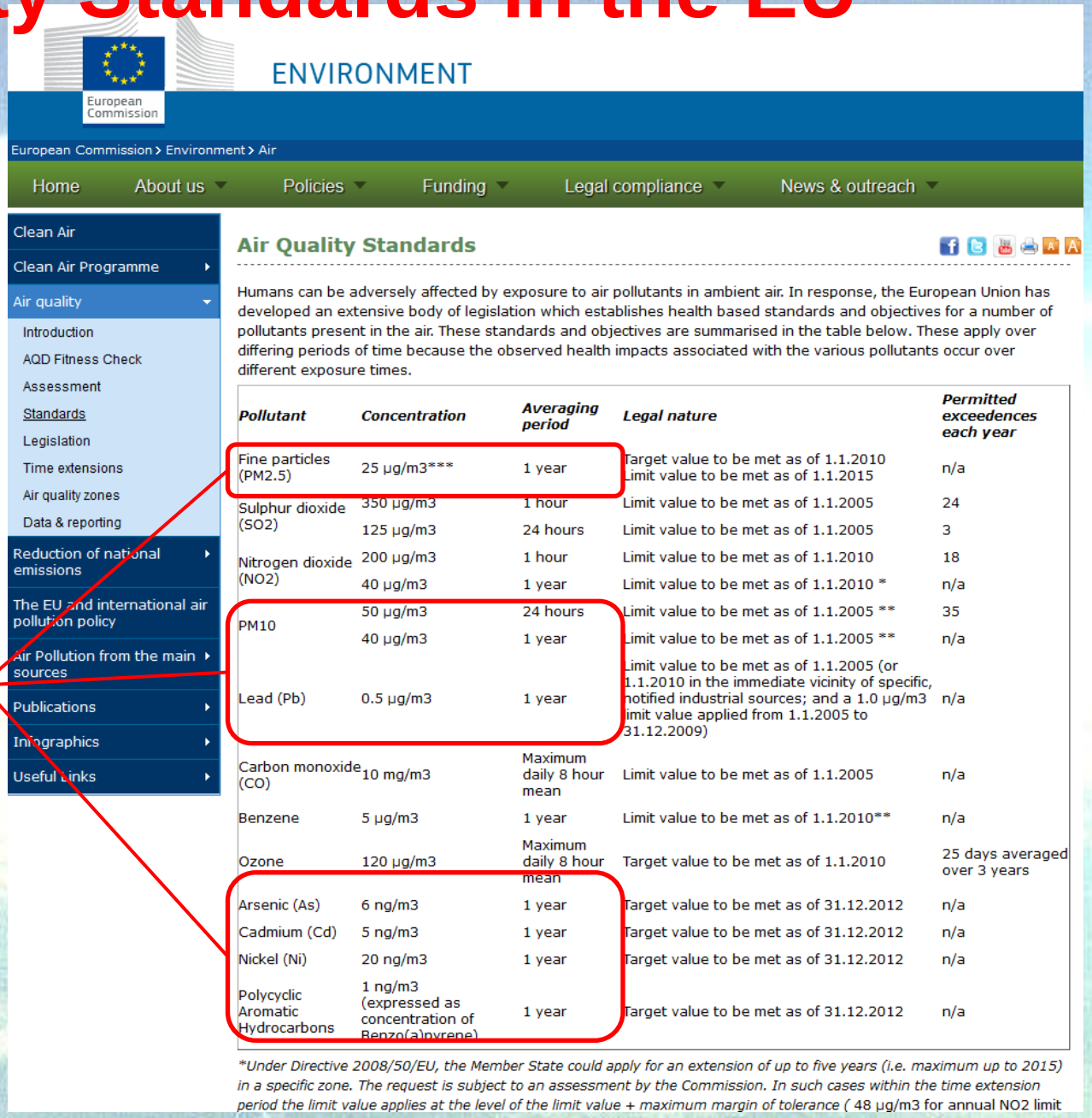
Air Quality Standards in the EU

pollutants always connected to aerosol particles



ENVIRONMENT

European Commission

European Commission › Environment › Air

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Air Quality Standards

Humans can be adversely affected by exposure to air pollutants in ambient air. In response, the European Union has developed an extensive body of legislation which establishes health based standards and objectives for a number of pollutants present in the air. These standards and objectives are summarised in the table below. These apply over differing periods of time because the observed health impacts associated with the various pollutants occur over different exposure times.

Pollutant	*Concentration*	*Averaging period*	*Legal nature*	*Permitted exceedences each year*
Fine particles (PM2.5)	25 µg/m3***	1 year	Target value to be met as of 1.1.2010 Limit value to be met as of 1.1.2015	n/a
Sulphur dioxide (SO2)	350 µg/m3	1 hour	Limit value to be met as of 1.1.2005	24
	125 µg/m3	24 hours	Limit value to be met as of 1.1.2005	3
Nitrogen dioxide (NO2)	200 µg/m3	1 hour	Limit value to be met as of 1.1.2010	18
	40 µg/m3	1 year	Limit value to be met as of 1.1.2010 *	n/a
PM10	50 µg/m3	24 hours	Limit value to be met as of 1.1.2005 **	35
	40 µg/m3	1 year	Limit value to be met as of 1.1.2005 **	n/a
Lead (Pb)	0.5 µg/m3	1 year	Limit value to be met as of 1.1.2005 (or 1.1.2010 in the immediate vicinity of specific, notified industrial sources; and a 1.0 µg/m3 limit value applied from 1.1.2005 to 31.12.2009)	n/a
Carbon monoxide (CO)	10 mg/m3	Maximum daily 8 hour mean	Limit value to be met as of 1.1.2005	n/a
Benzene	5 µg/m3	1 year	Limit value to be met as of 1.1.2010**	n/a
Ozone	120 µg/m3	Maximum daily 8 hour mean	Target value to be met as of 1.1.2010	25 days averaged over 3 years
Arsenic (As)	6 ng/m3	1 year	Target value to be met as of 31.12.2012	n/a
Cadmium (Cd)	5 ng/m3	1 year	Target value to be met as of 31.12.2012	n/a
Nickel (Ni)	20 ng/m3	1 year	Target value to be met as of 31.12.2012	n/a
Polycyclic Aromatic Hydrocarbons	1 ng/m3 (expressed as concentration of Benzo(a)pyrene)	1 year	Target value to be met as of 31.12.2012	n/a

**Under Directive 2008/50/EU, the Member State could apply for an extension of up to five years (i.e. maximum up to 2015) in a specific zone. The request is subject to an assessment by the Commission. In such cases within the time extension period the limit value applies at the level of the limit value + maximum margin of tolerance (* 48 µg/m3 for annual NO2 limit

Jan Hovorka, Air Quality Lab, Fac. Sci, Charles Univerzity, Czechia

AIR QUALITY- RESPONSIBLE BODY IN THE CZECHIA

CZECH HYDROMETEOROLOGICAL INSTITUTE

- conducts/maintains monitoring network
- on-line reports air quality

http://portal.chmi.cz/files/portal/docs/uoco/web_generator/actual_hour_data_CZ.html

- produces air quality maps

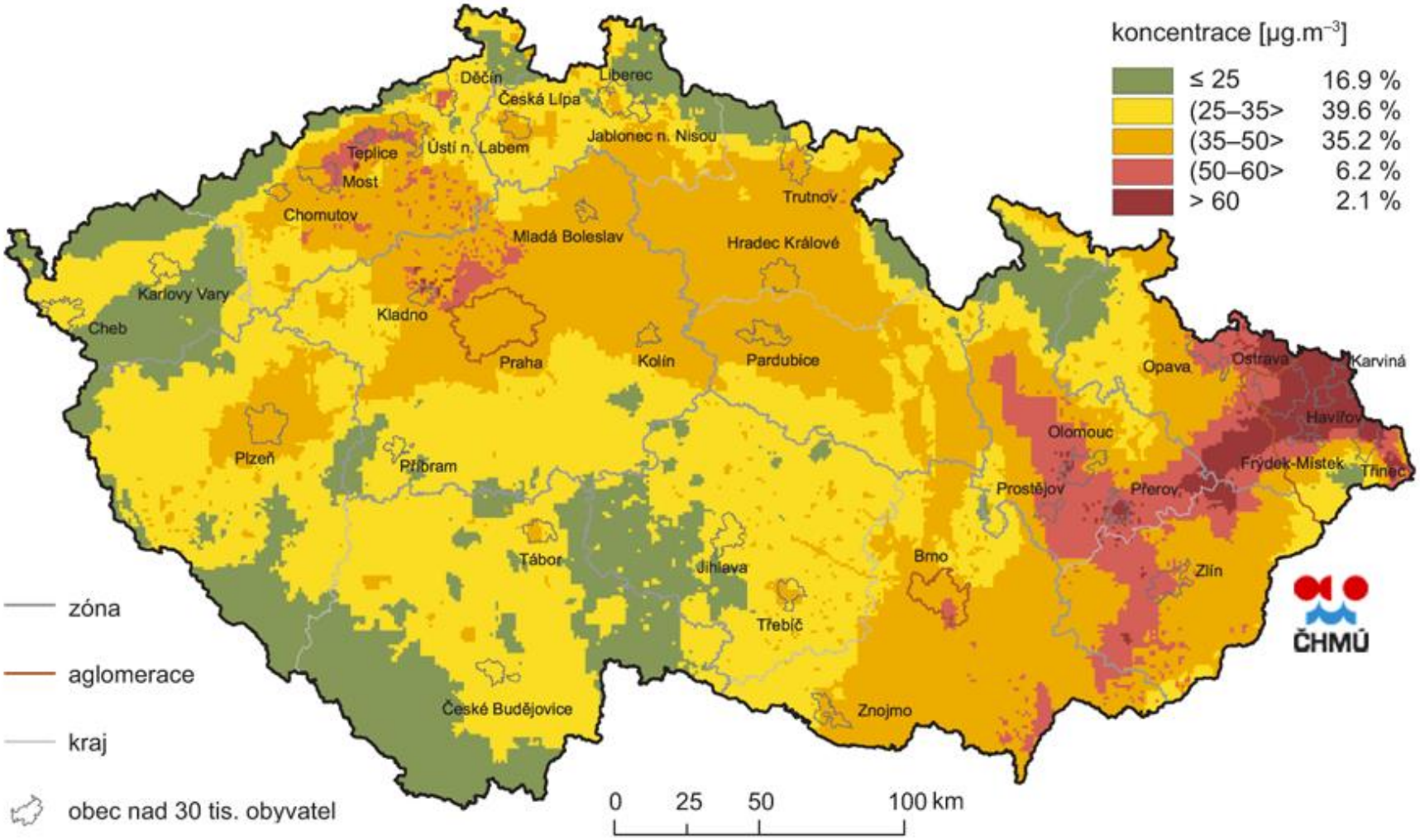
http://portal.chmi.cz/files/portal/docs/uoco/isko/grafroc/17groc/gr17cz/IV1_PM_CZ.html

- builds actualizes pollutant source databases

http://portal.chmi.cz/files/portal/docs/uoco/isko/grafroc/17groc/gr17cz/II_ovzd_CZ.html

24h PM_{10} exceedances in 2017

~ 8% area ~ 23 % population



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benzo(a)pyren

- hydrocarbon
- cause cancer

- forms during low temperature/oxygen combustion

bond to

aerosol particles

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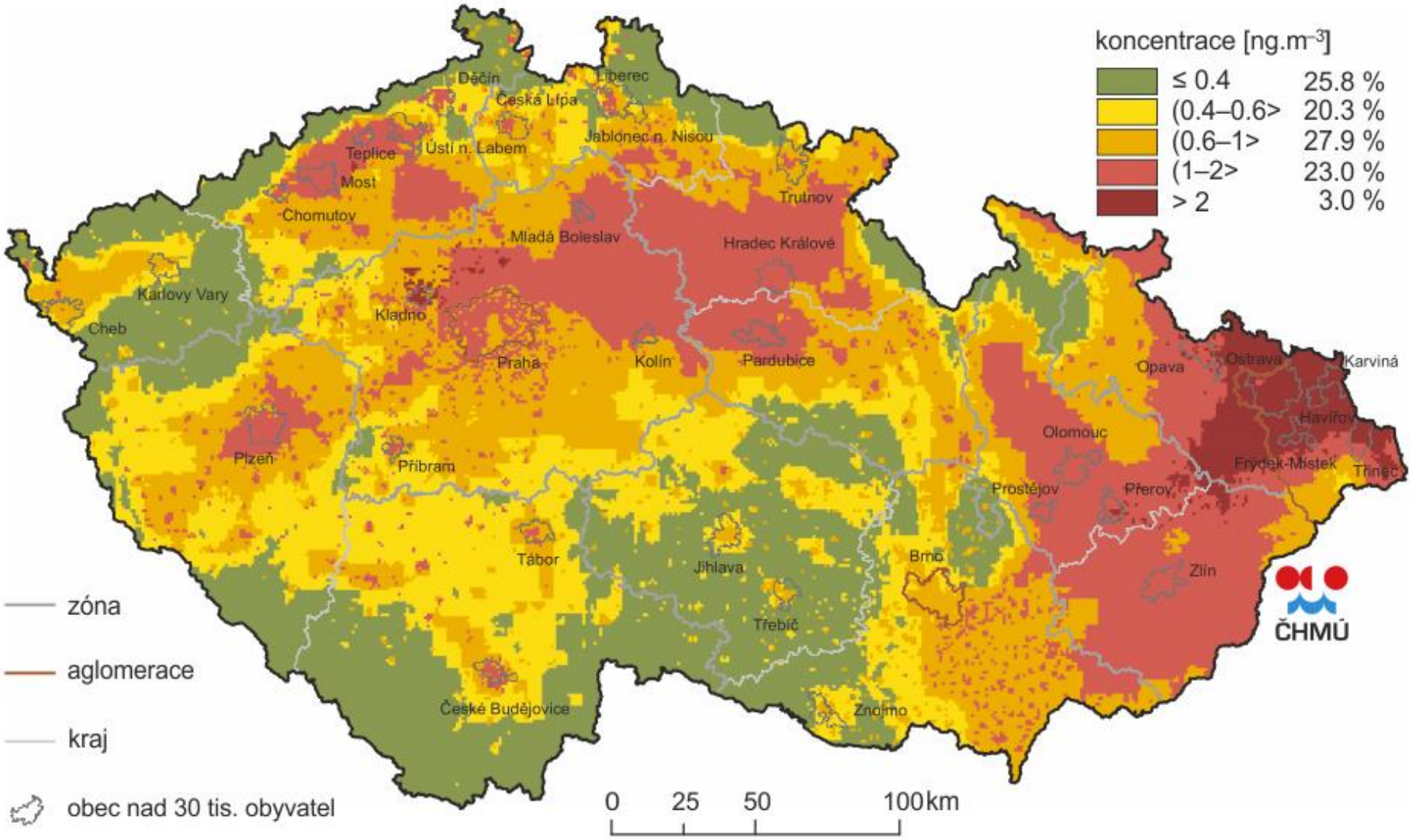
Benzo[a]pyrene exceedances in 2017

~26% area, ~62 % population



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Tool for air pollution source apportionment within EU?

- rapid exploration of air pollution sources down to medium-sized settlements

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European Commission

JOINT RESEARCH CENTRE

Air Quality Modeling

European Commission > EU Science Hub > SHERPA

SHERPA

Screening for High Emission Reduction Potential on Air

CONTACT

Background

SHERPA (*Screening for High Emission Reduction Potential on Air*) is a Java/Python tool, which allows for a rapid exploration of potential air quality improvements resulting from national/regional/local emission reduction measures. The tool has been developed with the aim of supporting national, regional and local authorities in the design and assessment of their air quality plans.The tool is based on the relationships between emissions and concentration levels, and can be used to answer the following type of questions:

- What is the potential for local action in my domain?
- What are the priority activity, sectors and pollutants on which to take action and,
- What is the optimal dimension that my policy action domain (city, region...) should have to be efficient?"

The SHERPA tool is distributed with EU-wide data on emissions and source-receptor models (spatial resolution of roughly 7x7 km2), so that it is very easy to start working on any region/local domain in Europe.

More specifically, SHERPA logical pathway is implemented through the following steps:

Advanced methods of air pollution source apportionment?

Receptor modelling

- advanced analysis of comprehensive datasets recorded in receptor

- US-EPA Positive Matrix Factorization (PMF) 5.0 model

https://www.epa.gov/air-research/positive-matrix-factorization-model-environmental-data-analyses

PMF = Positive Matrix Factorization

- Factor analyzis of datasets of chemical compostion aerosol particles collected at selected site – **RECEPTOR**
- Chemical composition aof aersol partilces is result of **linear combination** source contribution

P = No. sources

$$x_{ij} = \sum_{p=1}^{P} g_{ip} f_{pj} + e_{ij}$$

i-th conc.
j-th element

rezidua
i-th value
j-th element

mass contribution of
p-th source in i-th sample

conc. of j-th element in
1g mass of p-th source

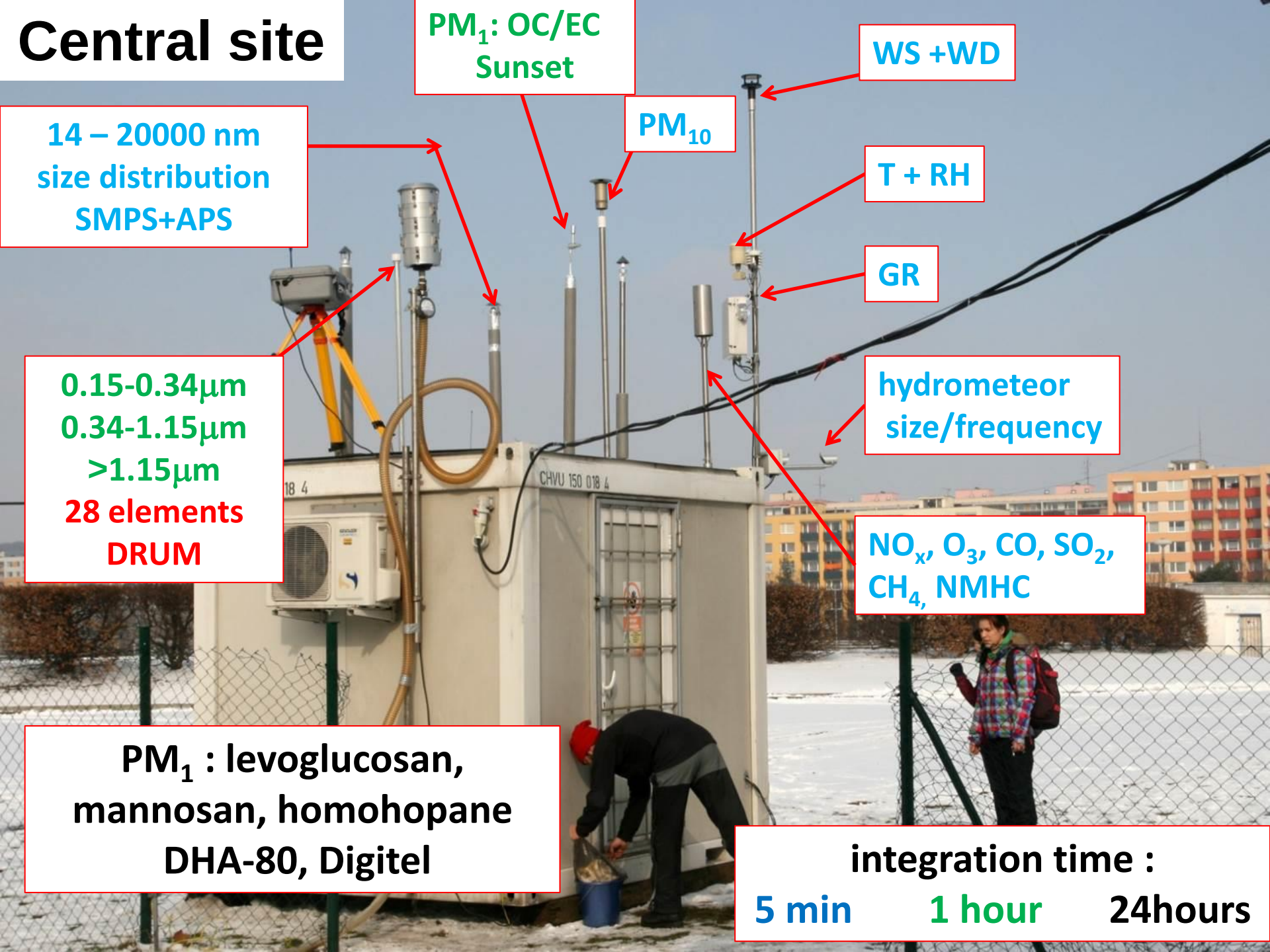
$$\mathbf{X} = \mathbf{GF} + \mathbf{E}$$

PMF searchs for a minimum value of Q

$$Q = \sum_{i=1}^{n}\sum_{j=1}^{m}(e_{ij}/s_{ij})^2 = \sum_{i=1}^{n}\sum_{j=1}^{m}(x_{ij} - \sum_{h=1}^{p} g_{ih} f_{hj})^2 / s_{ij}^2$$

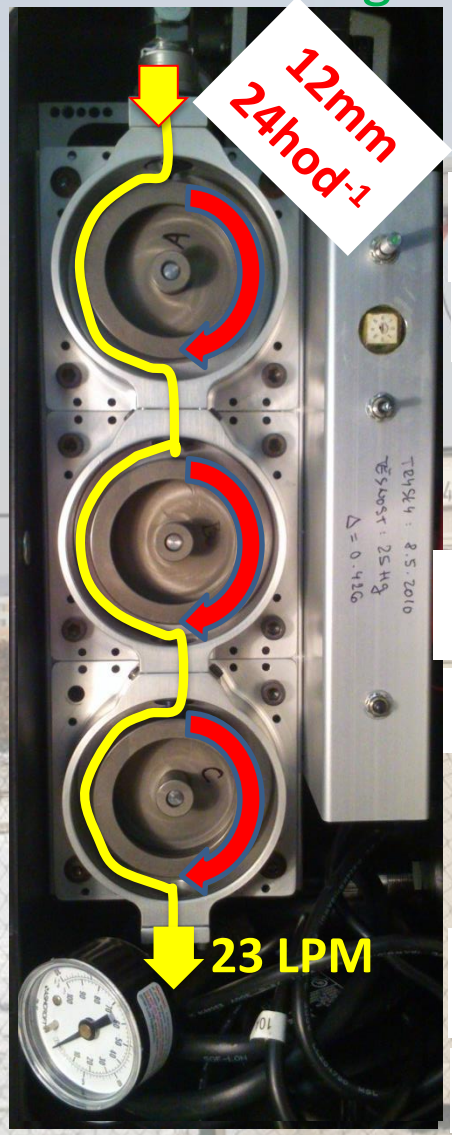
uncertainty of
j-th element
in i-th conc.

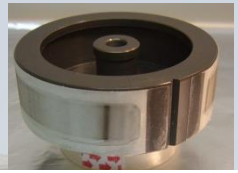
KEY PARAMETR: DATAMATRIX SIZE X


Central site
PM1: OC/EC
Sunset
WS +WD
14 – 20000 nm
size distribution
SMPS+APS
PM10
T + RH
GR
0.15-0.34µm
0.34-1.15µm
>1.15µm
28 elements
DRUM
hydrometeor
size/frequency
NOx, O3, CO, SO2,
CH4, NMHC
PM1 : levoglucosan,
mannosan, homohopane
DHA-80, Digitel
integration time :
5 min
1 hour
24hours

3 DRUM

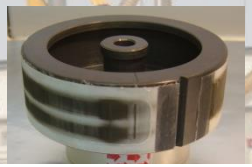
Davis Rotating Universal Monitor





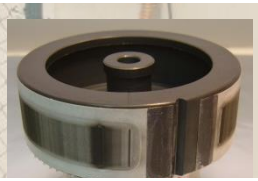
COARSE

1.15-10µm



FINE

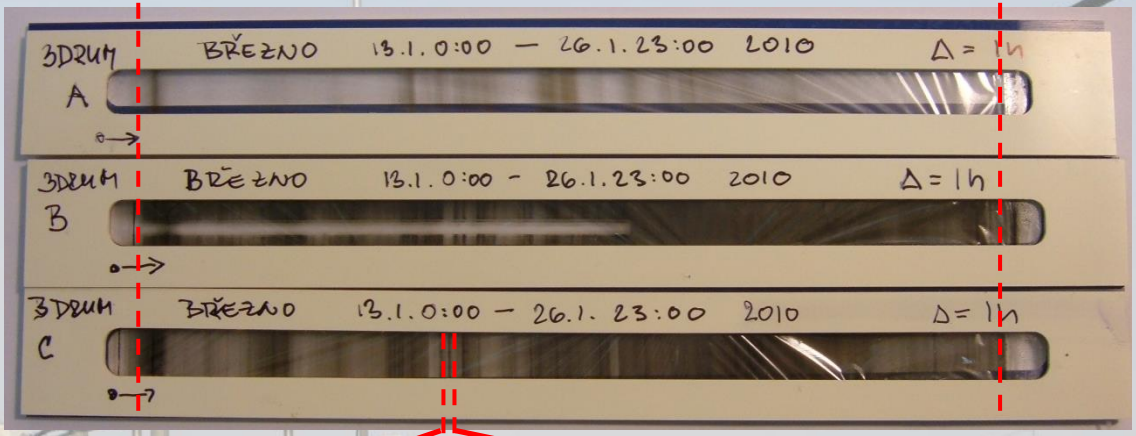
0.35-1.15µm



FINE

0.12-0.35µm

~17cm = 14 days (336 hours)



0.5mm = 1 hour

28 elements

Na, Mg, Al, Si, P, S, Cl, K, Ca, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, As, Se, Br, Rb, Sr, Y, Zr, Mo, Pb

synchrotron X-ray fluorescence (S-XRF), Lawrence Berkeley National Laboratory

14 DAYS = DATA MATRIX

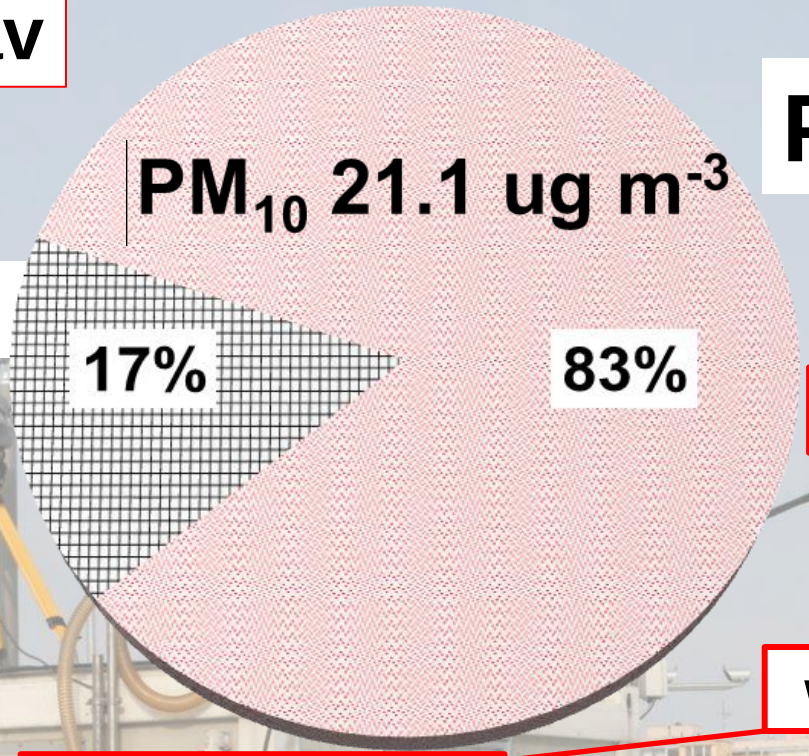
300 X 28

Mladá Boleslav

US-EPA, PMF 4.2.0.0.

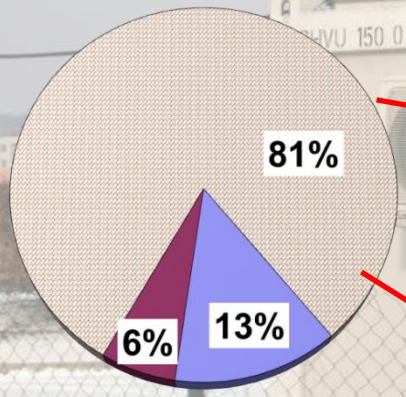
PM_{10} sources

PM_{10} 21.1 ug m^{-3}



coarse aerosol

fine aerosol



combustion

76%

industry

7%

car brake abrasion + road dust = transportation

17%