Alternative Methods of Air Quality Measurements

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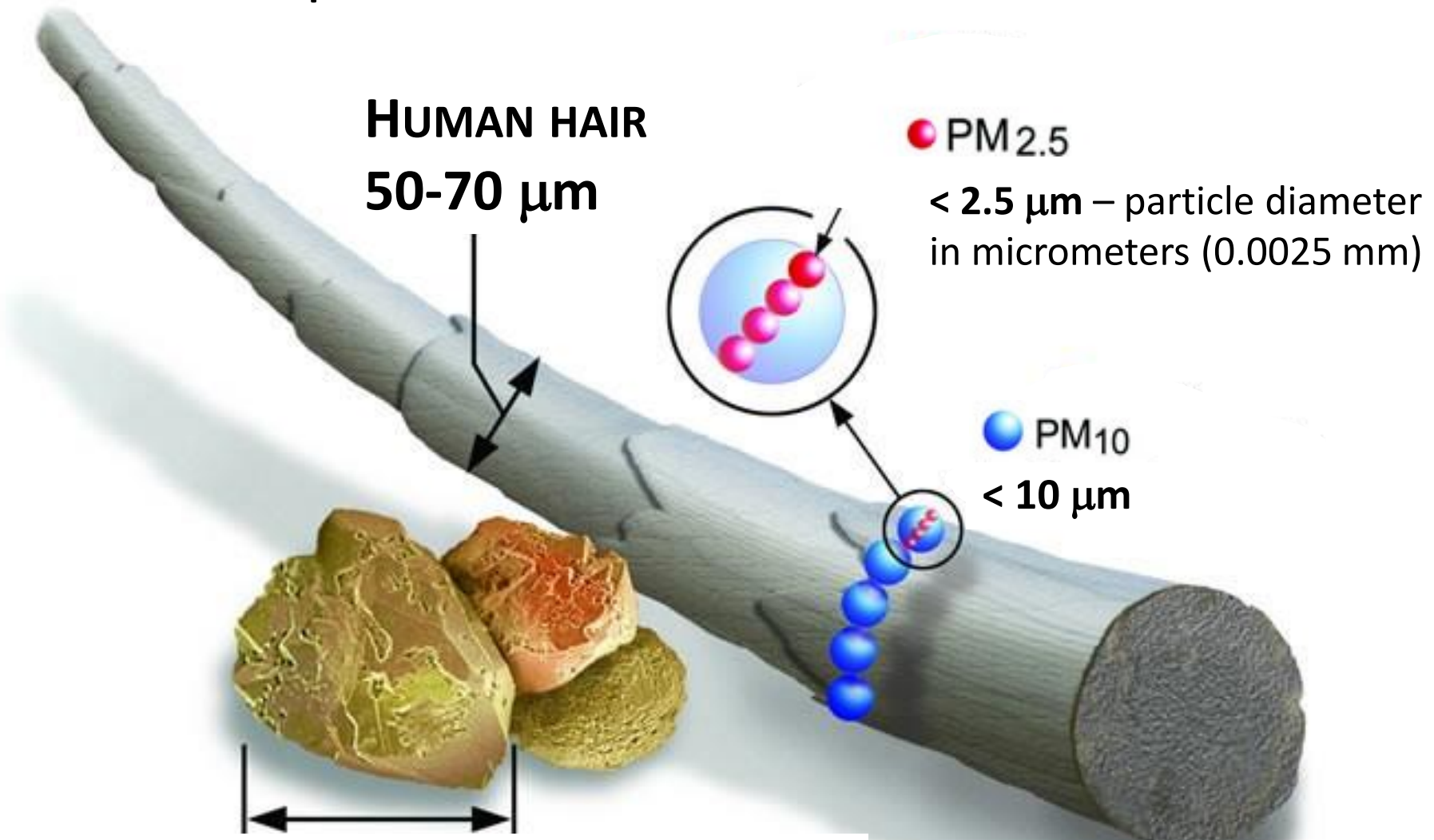
Atmospheric Aerosol – Particle Sizes



Nanoparticles (invisible)

PM_{10}

$PM_{2.5}$

PM_1

Lungs

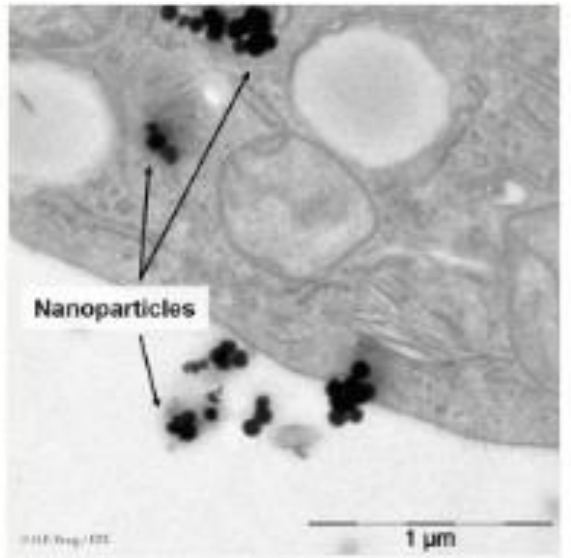
Blood Vessel with red Blood Cells

Lung Epithelial Cells

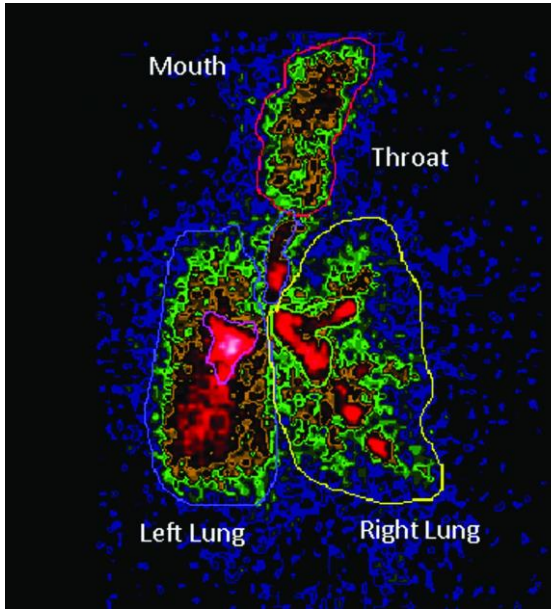
Alveolus

Macrophages

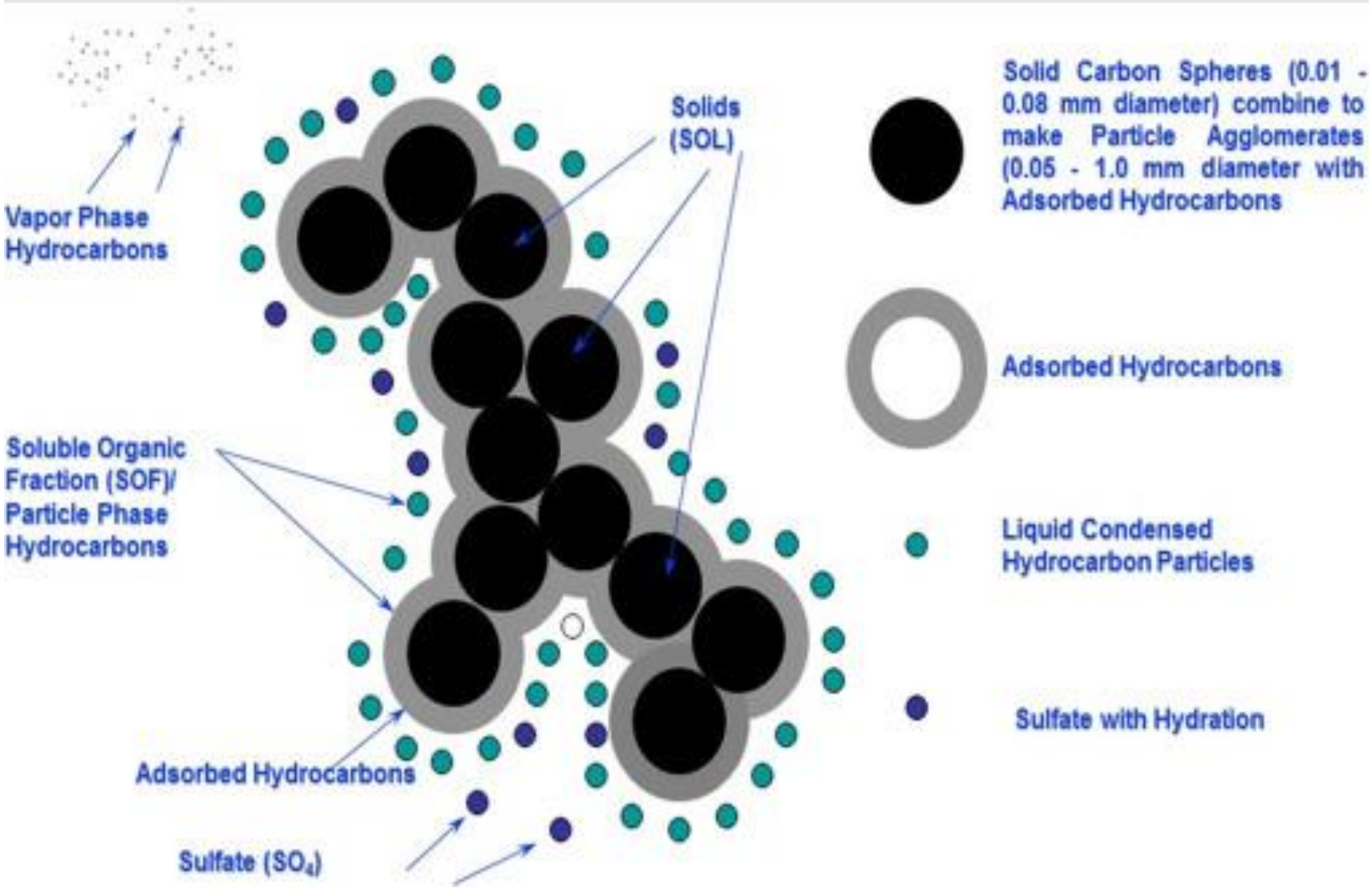
Dentritic Cell

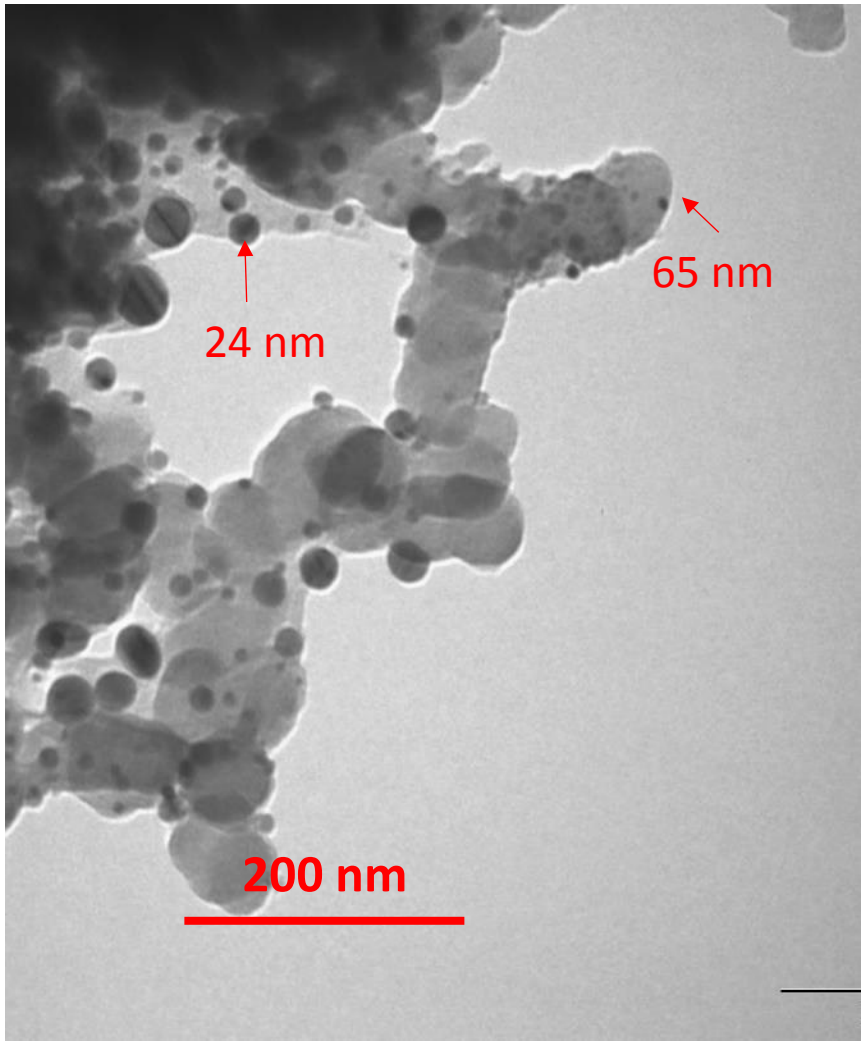


TEM image of A549 cells with hematite nanoparticles (50 nm)



Why can be Aerosol Particles so Dangerous?





Polycyclic Aromatic Hydrocarbons

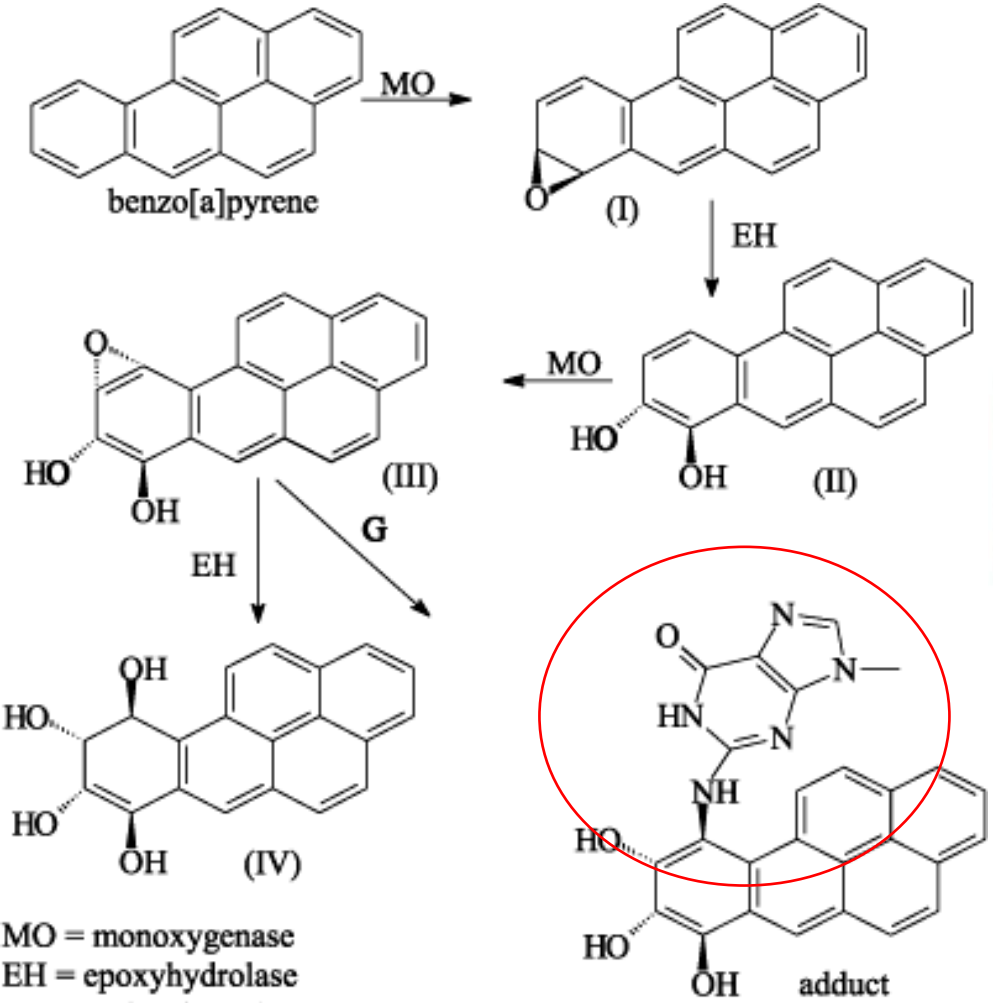
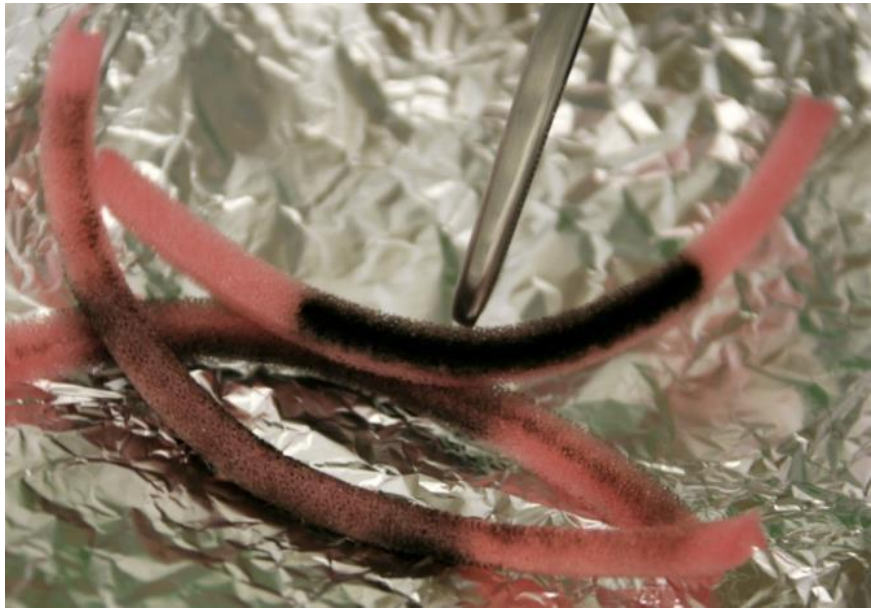
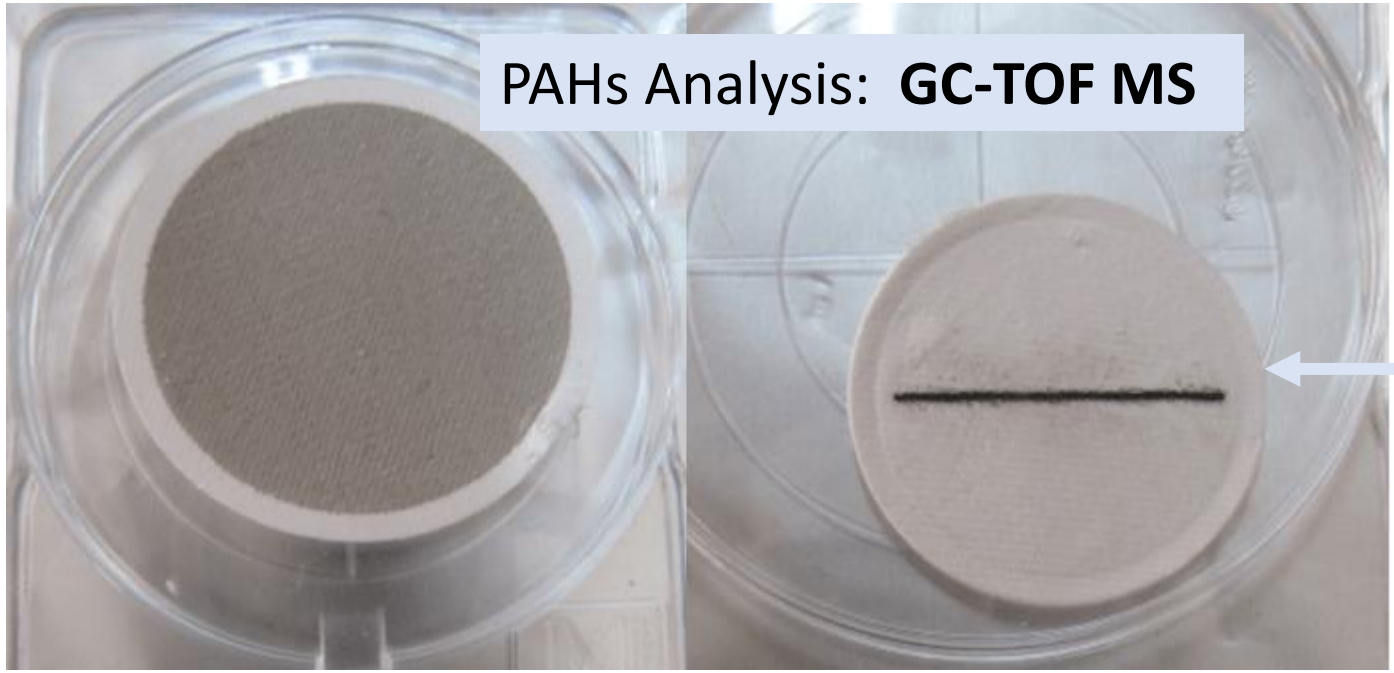


Figure 1. *In vivo* oxidative metabolic pathway of benzo[a]pyrene *via* hydrophilic intermediates (I-IV) and formation of DNA adducts with guanine base.





PAHs Analysis: **GC-TOF MS**

2.5 - 10 µm

1 – 2.5 µm

0,5 – 1 µm

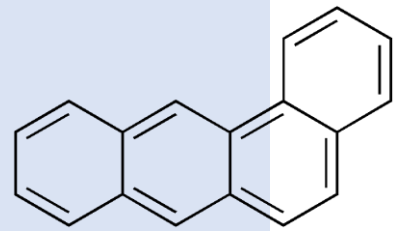
0,25 – 0,5 µm

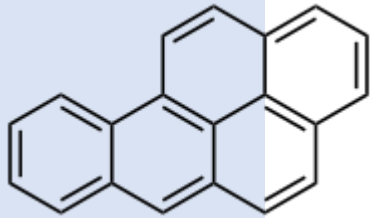
< 0,25 µm

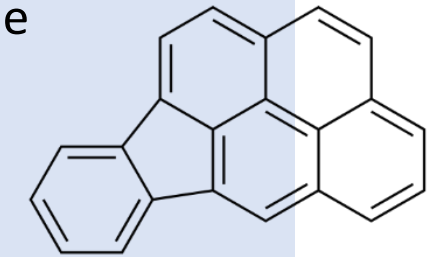
Pump
9 l.min^{-1}
1h

Carcinogenic PAHs (c-PAHs):

B[a]A	Benzo[a]anthracene
CHRY	Chrysene
B[b]F	Benzo[b]fluorantane
B[k]F	Benzo[k]fluorantane
B[a]P	Benzo[a]pyren
Db[a.h]A	Dibenzo[a.h]anthracene
B[g.h.i]P	Benzo[g.h.i]perylene
I[1.2.3-cd]P	Ideno(1.2.3-cd)pyrene



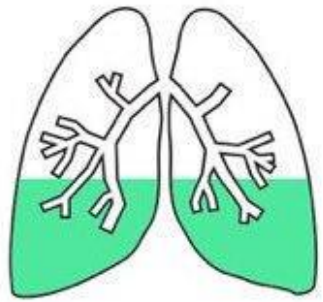




What causes the most deaths?

THE
INVISIBLE KILLER

Air pollution may not always be visible, but it can be deadly.



35%
OF DEATHS FROM
COPD
(PULMONARY DISEASE)

BREATHELIFE.
Clean Air. Healthy Future.

World Health Organization

CLIMATE & CLEAN AIR COALITION

2016 ranking		% change 2005-2016
1	Ischemic heart disease	39.8%
2	COPD	24.2%
3	Cerebrovascular disease	20.4%
4	Lower respiratory infect	-33.6%
5	Diarrheal diseases	-41.9%
6	Diabetes	58.8%
7	Neonatal encephalopathy	-26.5%
8	Road injuries	6.7%
9	Chronic kidney disease	36.9%
10	Tuberculosis	-29.9%
11	Asthma	-0.3%
12	Other neonatal	-31.6%

Top 10 causes of death in 2016 and percent change, 2005-2016, all ages, number

WHO:

- Globally **3 milion deaths** every year (ambient air pollution)
- Globally **4.3 milion deaths** every year (indoor air pollution - cooking)
- **92%** of World population lives at places where air quality limits are exceeded

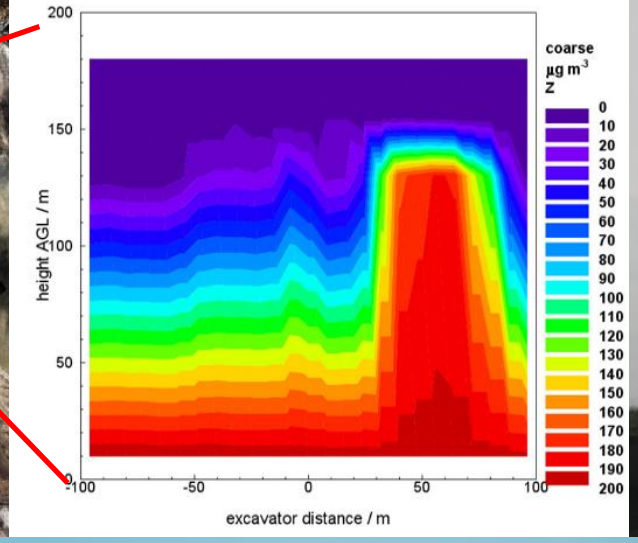
EEA:

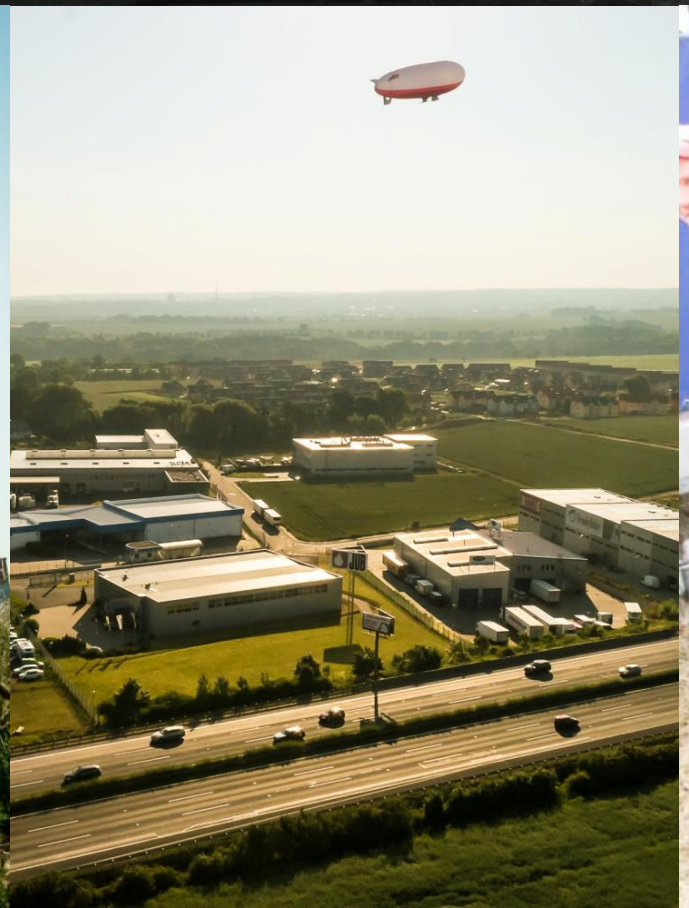
- In Europe **>400 000** premature deaths

IARC:

- Air pollution classified as carcinogenic


BGI900
High Volume
Cascade Impactor

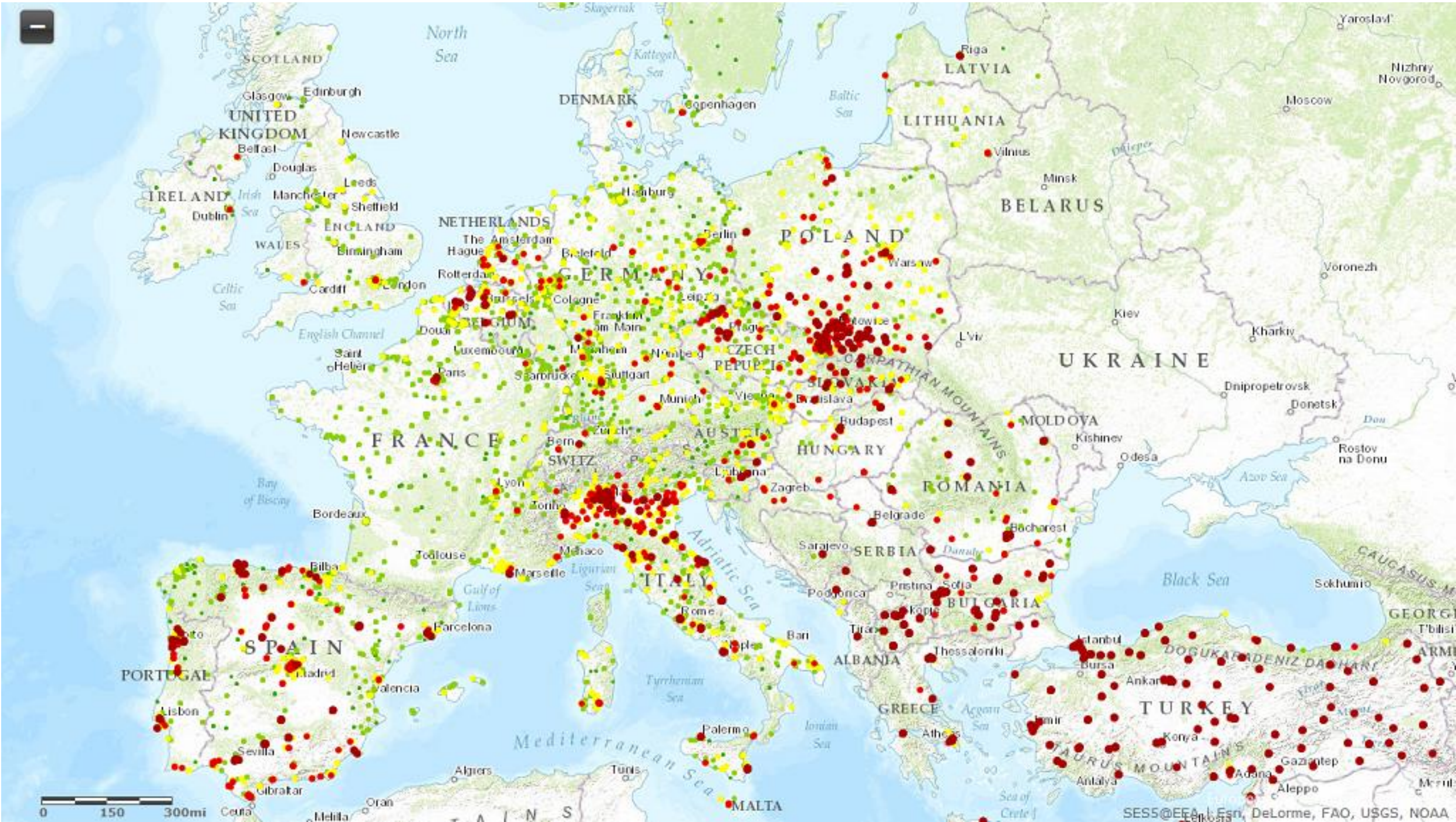

height AGL / m
200
150
100
50
0
-100
-50
0
50
100
excavator distance / m
coarse
µg m-3
z
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200

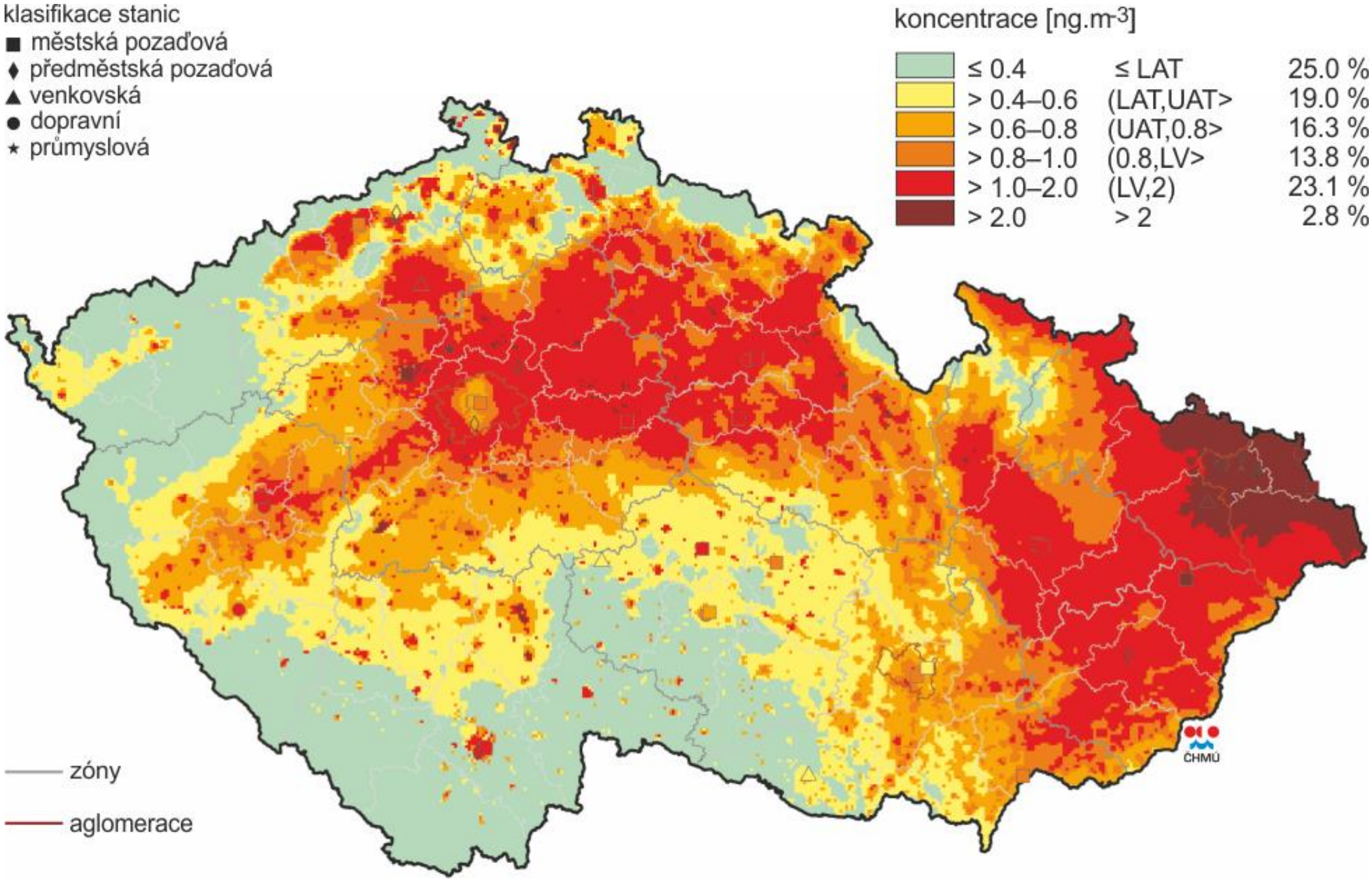


Classical Approach of Air Quality Measurements

- Network of air quality measuring stations (operated mostly by state agencies)
- Expensive instruments and service
- High precision and accuracy, reliability
- Comparability within Europe
- Long-term data (trends)

- Limited amount of stations
- inaccuracies in spatial modeling and predictions


North Sea
SCOTLAND
Glasgow
Edinburgh
UNITED KINGDOM
Newcastle
Belfast
Douglas
IRELAND
Irish Sea
Dublin
Manchester
Leeds
Sheffield
ENGLAND
WALES
Birmingham
Cardiff
London
Celtic Sea
English Channel
Saint Helier
DENMARK
Kattegat
Copenhagen
Baltic Sea
Skagerrak
Riga
LATVIA
LITHUANIA
Vilnius
Minsk
BELARUS
Moscow
Yaroslavl'
Nizhniy Novgorod
Voronezh
Kharkiv
Hamburg
NETHERLANDS
Amsterdam
The Hague
Rotterdam
Bielefeld
Berlin
GERMANY
POLAND
Warsaw
Cologne
Leipzig
Frankfurt am Main
Prague
CZECH REPUBLIC
Douai
Luxembourg
Nurnberg
Saarbrucken
Stuttgart
Paris
Munich
Vienna
Bratislava
SLOVAKIA
CARPATHIAN MOUNTAINS
L'viv
Kiev
UKRAINE
Dnipropetrovsk
Donetsk
MOLDOVA
Kishinev
Odesa
Rostov na Donu
Azov Sea
Budapest
HUNGARY
AUSTRIA
FRANCE
Bern
Zurich
SWITZ.
Lyon
Ljubljana
Zagreb
ROMANIA
Bordeaux
Bay of Biscay
Belgrade
Bucharest
Sarajevo
SERBIA
Toulouse
Monaco
Marseille
Ligurian Sea
Gulf of Lions
ITALY
Adriatic Sea
Black Sea
Sokhumi
Bilbao
Pristina
Sofia
BULGARIA
Podgorica
Skopje
Porto
SPAIN
Barcelona
Rome
Bari
Tirana
Istanbul
Bursa
ALBANIA
Thessaloniki
PORTUGAL
Madrid
Valencia
Naples
Tyrrhenian Sea
Ankara
TURKEY
Lisbon
GREECE
Aegean Sea
Izmir
Palermo
Ionian Sea
Athens
Konya
Mediterranean Sea
Sevilla
TAURUS MOUNTAINS
Gaziantep
Adana
Antalya
Aleppo
Algiers
Tunis
Gibraltar
Oran
Ceuta
Melilla
MALTA
Sea of Crete
GEORGIA
T'bilisi
0 150 300mi
SES5@EEA | Esri, DeLorme, FAO, USGS, NOAA



Obr. IV.2.1 Pole roční průměrné koncentrace benzo[*a*]pyrenu, 2016

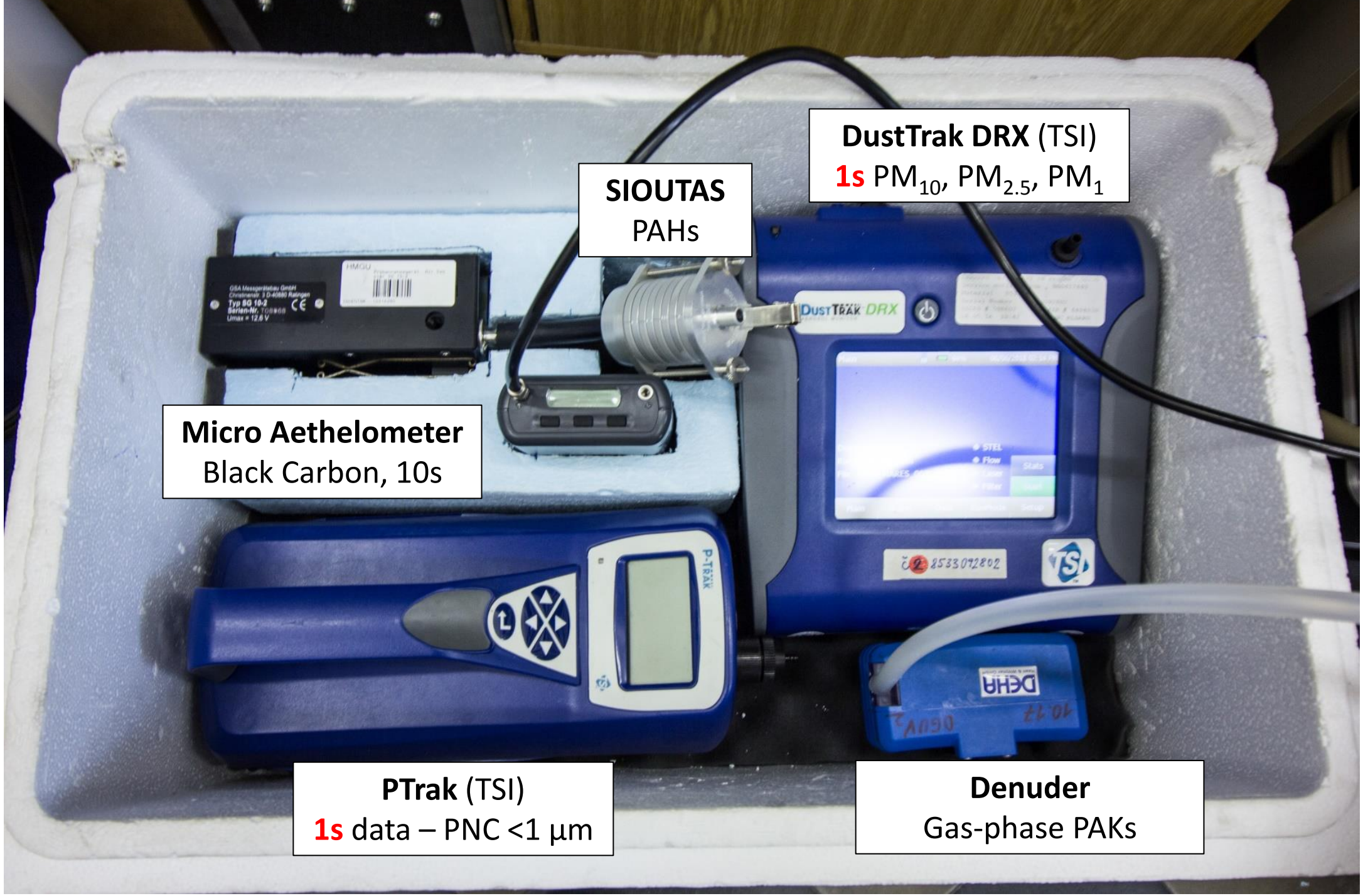
The Concept of Mobile Measurements

- The lack of information about **micro-scale PM concentrations** by stationary measurements
- **Temporal / Spatial variability** evaluation
- **Hot-spots** identification
- **Real PM exposure**

1. Prague Campaign

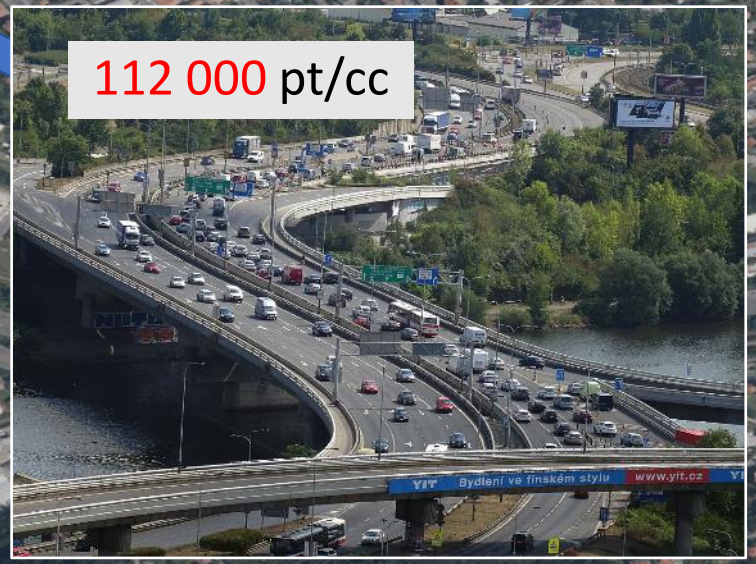

7. 6. 2018 (10:35-14:10), 6,9 km
PNC (pt/cm3)
0 - 10000
10 000 - 15 000
15 000 – 25 000
25 000 – 250 000


ZACHRAŇUJ
MĚSTO


DustTrak DRX (TSI)
1s PM_{10}, $PM_{2.5}$, PM_1
SIOUTAS
PAHs
Micro Aethelometer
Black Carbon, 10s
PTrak (TSI)
1s data – PNC <1 µm
Denuder
Gas-phase PAKs


DRX
PTRAK
DRX2

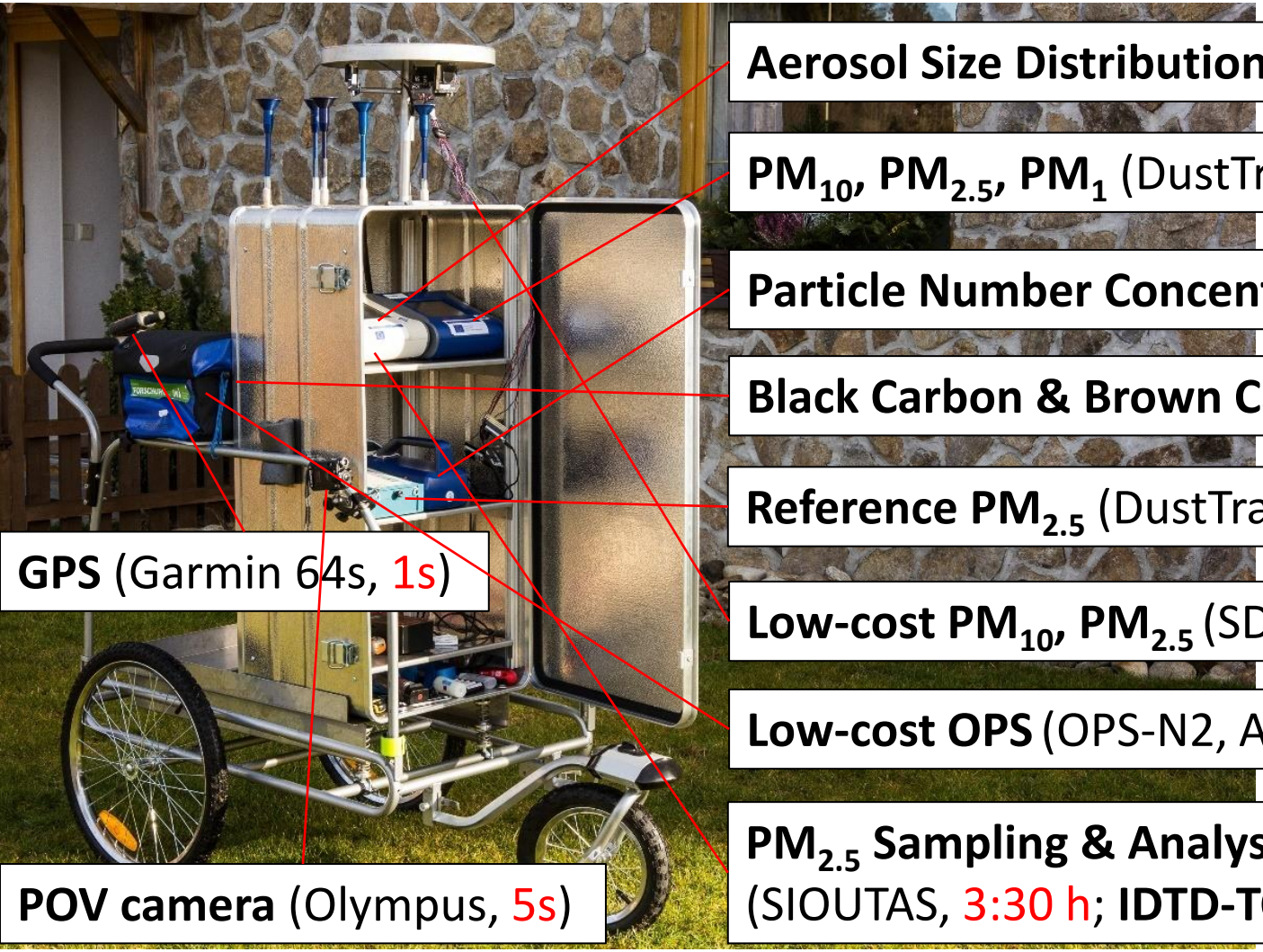
PNC <1 µm conc. inside trailer



Pt/cc

- 0-3000
- 3000-5000
- 7000-10 000
- 10 000-13 000
- 13 000-15 000
- 15 000-20 000
- 20 000-25 000
- 25 000 – 250 000

2. Augsburg Campaign - Experimental Set-up



GPS (Garmin 64s, 1s)

POV camera (Olympus, 5s)

Aerosol Size Distribution (OPS, TSI, 1s / 11E, GRIMM, 6s)

PM_{10}, $PM_{2.5}$, PM_1 (DustTrak DRX, 1s)

Particle Number Concentration (PTrak, TSI, 1s)

Black Carbon & Brown Carbon (MA 200, AethLabs, 10s)

Reference $PM_{2.5}$ (DustTrak, 1s)

Low-cost PM_{10}, $PM_{2.5}$ (SDS011, 1s)

Low-cost OPS (OPS-N2, AlphaSense, 1s)

$PM_{2.5}$ Sampling & Analysis
(SIOUTAS, 3:30 h; **IDTD-TOF-GC-MS**)

26. 9. 2018 (12:51-16:40), 11,4 km

PM_1 (µg/m^3)

- 0 - 10
- 10 - 20
- 20 - 30
- 30 - 40
- >40

Construction

Collocation at the station

N

0 0.125 0.25 0.5 0.75 1 Kilometers

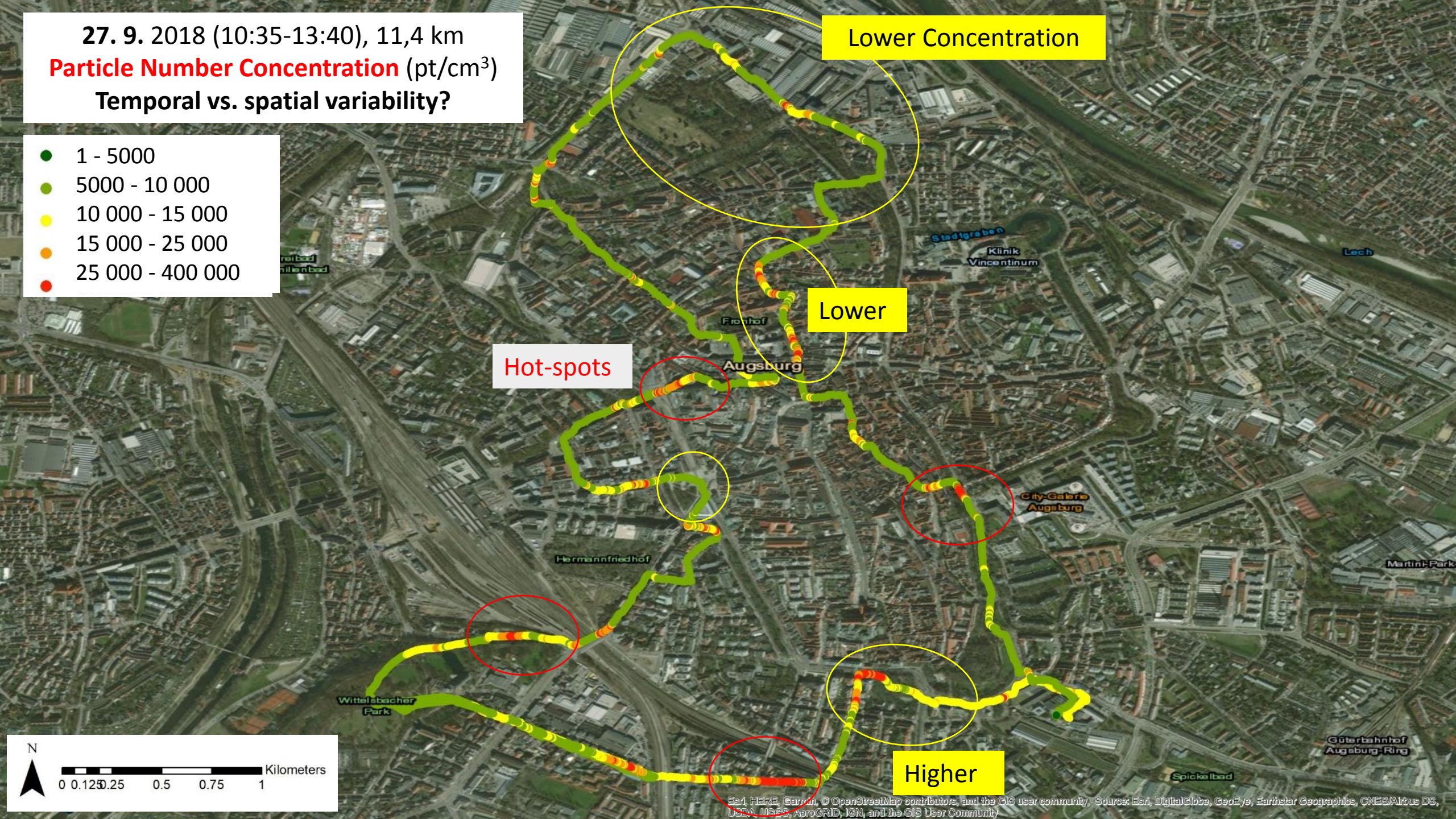
26. 9. 2018 (12:51-16:40), 11,4 km

Particle Number Concentration (pt/cm^3)

- 1 - 5000
- 5000 - 10 000
- 10 000 - 15 000
- 15 000 - 25 000
- 25 000 - 400 000

N

0 0.125 0.25 0.5 0.75 1 Kilometers


27. 9. 2018 (10:35-13:40), 11,4 km
Particle Number Concentration (pt/cm³)
Temporal vs. spatial variability?
1 - 5000
5000 - 10 000
10 000 - 15 000
15 000 - 25 000
25 000 - 400 000
Lower Concentration
Lower
Hot-spots
Higher
Augsburg
Hauptbahnhof
Stadtgraben
Klinik Vincentinum
Lech
City-Galerie Augsburg
Hermannfriedhof
Wittelsbacher Park
Martini-Park
Güterbahnhof Augsburg-Ring
Spickelbad
N
Kilometers
0 0.125 0.25 0.5 0.75 1
Esri, HERE, Garmin, © OpenStreetMap contributors, and the GIS user community, Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

26. 9. 2018 (12:51-16:40), 11,4 km

PM_{10} (µg/m³)

DustTrak **DRX** (inner) vs. **LowCost** (outer)

- 0 - 10
- 10 - 20
- 20 - 30
- 30 - 40
- >40

N

0 0.125 0.25 0.5 0.75 1 Kilometers

Lowcost ~ DRX

Lowcost < DRX

Low-cost does not see

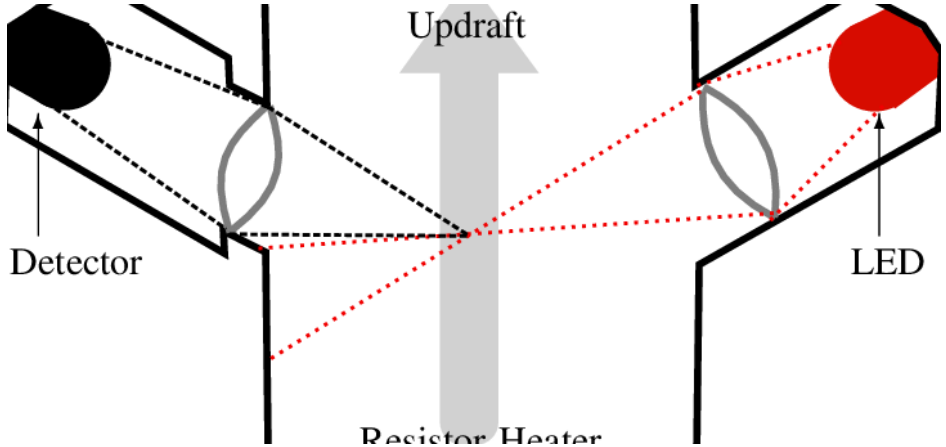
Low-cost Instrument SDS-011

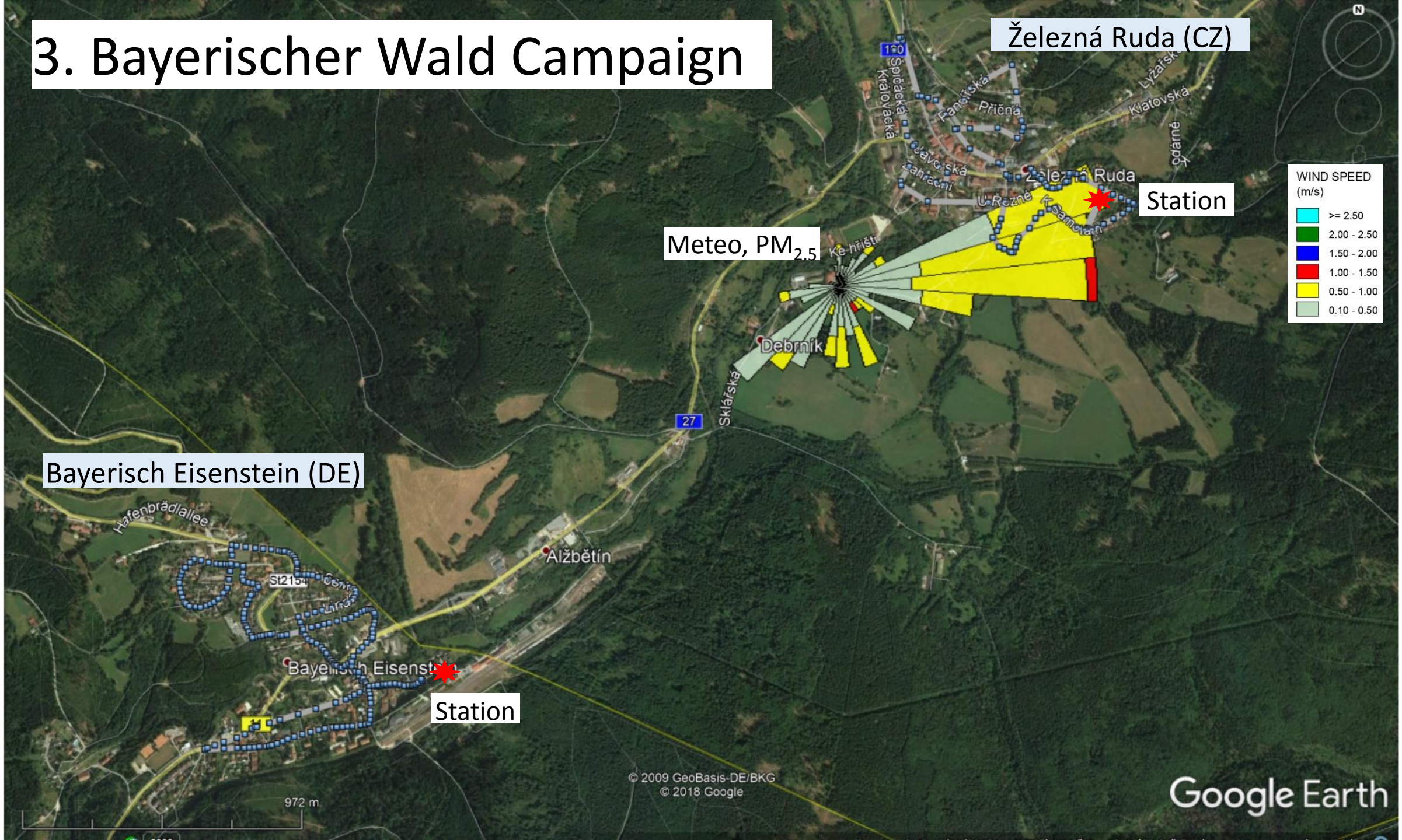
- **Cheap** - 100 USD (vs. 10 000 USD – professional instrument)
- **Larger network** – better more less precise instrument than one precise?
- **Citizen science** – people awareness
- Mobile applications, on-line maps and services

(a)

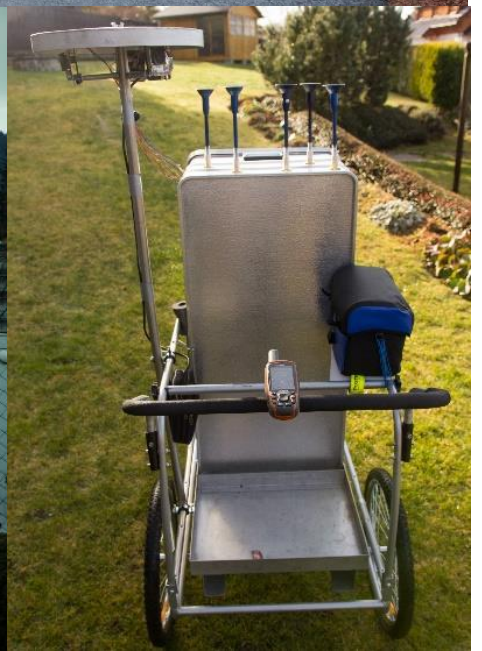
(b)

- **Lower precision**
- Need of intercomparisons
- Need of “standard operation plan”



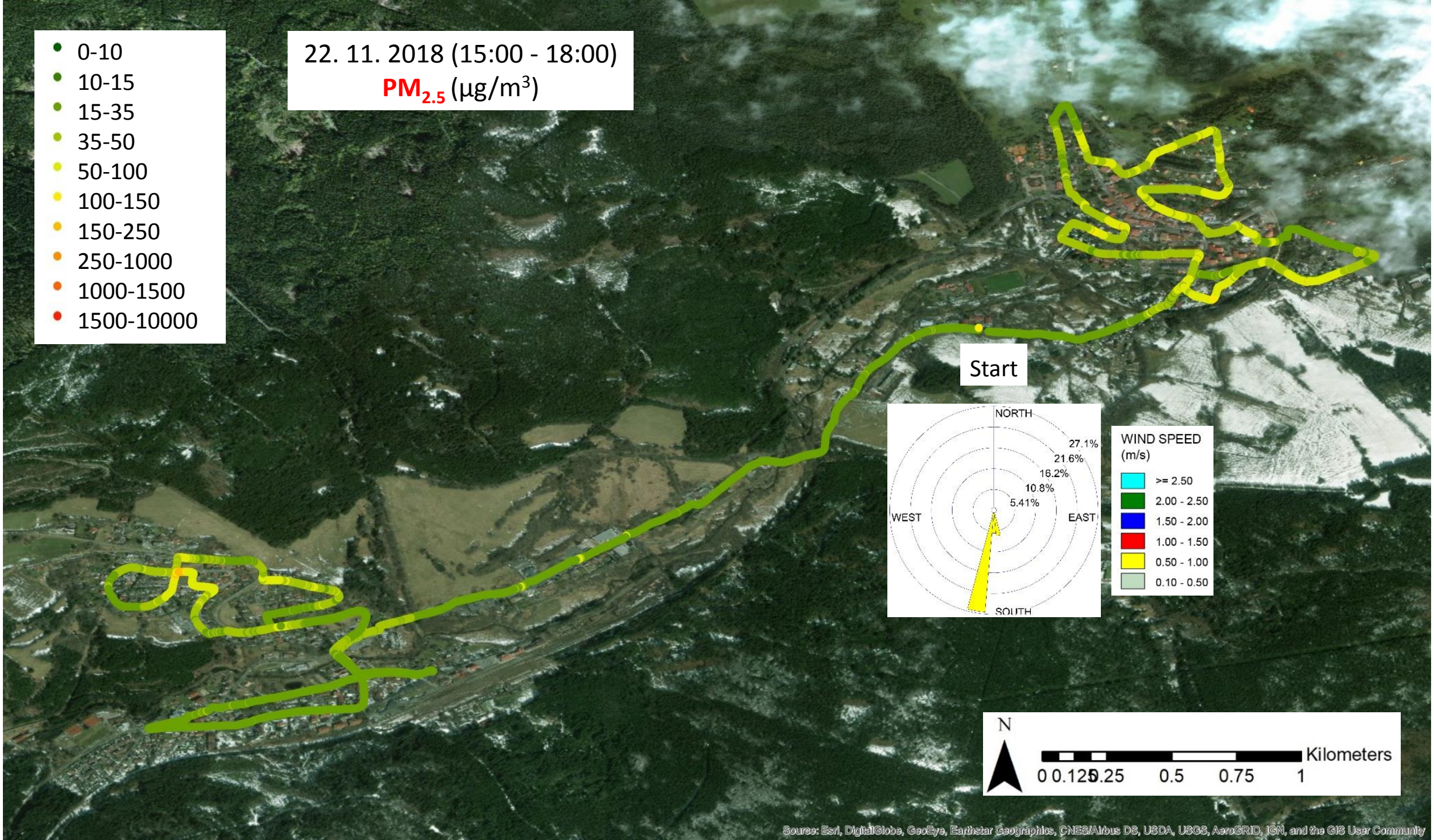

3. Bayerischer Wald Campaign
Železná Ruda (CZ)
Station
Meteo, PM2.5
WIND SPEED (m/s)
>= 2.50
2.00 - 2.50
1.50 - 2.00
1.00 - 1.50
0.50 - 1.00
0.10 - 0.50
Debrník
Alžbětín
Bayerisch Eisenstein (DE)
Station
© 2009 GeoBasis-DE/BKG
© 2018 Google
Google Earth

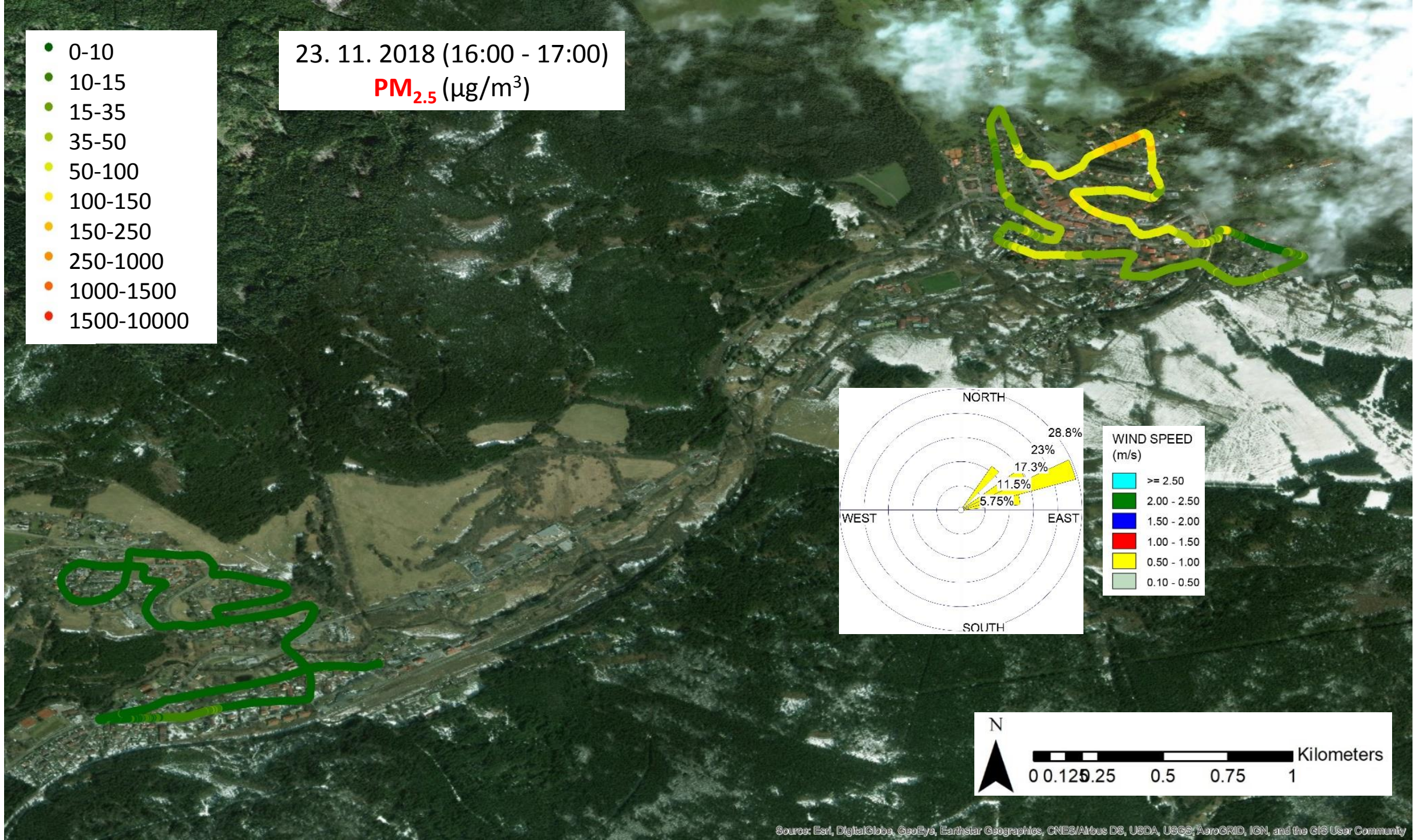

MOBILE
viewpoint

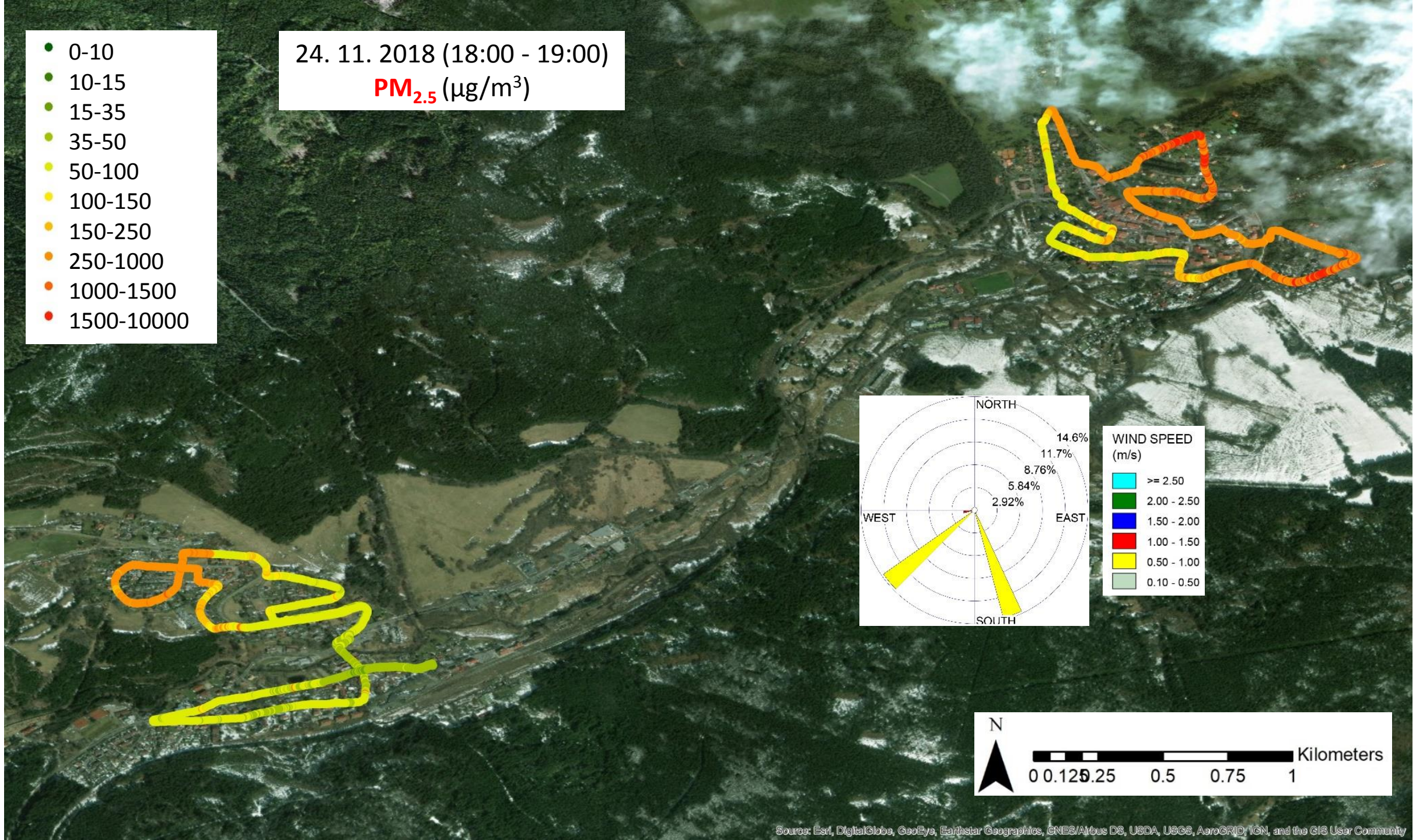



Jan Bendl koordinátor měření, Železná Ruda
patagonia


Vyrážíme na procházky každé dvě hodiny.
Začínáme ráno v pět hodin a pokračujeme do osmi do večera.
Jürgen Schnelle-Kreis koordinátor měření, Eisenstein


0-10
10-15
15-35
35-50
50-100
100-150
150-250
250-1000
1000-1500
1500-10000
22. 11. 2018 (15:00 - 18:00)
PM2.5 (µg/m3)
Start
NORTH
EAST
SOUTH
WEST
27.1%
21.6%
16.2%
10.8%
5.41%
WIND SPEED (m/s)
>= 2.50
2.00 - 2.50
1.50 - 2.00
1.00 - 1.50
0.50 - 1.00
0.10 - 0.50
N
Kilometers
0 0.125 0.25 0.5 0.75 1
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community


0-10
10-15
15-35
35-50
50-100
100-150
150-250
250-1000
1000-1500
1500-10000
23. 11. 2018 (16:00 - 17:00)
PM2.5 (µg/m3)
NORTH
28.8%
23%
17.3%
11.5%
5.75%
WEST
EAST
SOUTH
WIND SPEED (m/s)
>= 2.50
2.00 - 2.50
1.50 - 2.00
1.00 - 1.50
0.50 - 1.00
0.10 - 0.50
N
Kilometers
0 0.125 0.25 0.5 0.75 1
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community


0-10
10-15
15-35
35-50
50-100
100-150
150-250
250-1000
1000-1500
1500-10000
24. 11. 2018 (18:00 - 19:00)
PM2.5 (µg/m3)
NORTH
14.6%
11.7%
8.76%
5.84%
2.92%
WEST
EAST
SOUTH
WIND SPEED (m/s)
>= 2.50
2.00 - 2.50
1.50 - 2.00
1.00 - 1.50
0.50 - 1.00
0.10 - 0.50
N
Kilometers
0 0.125 0.25 0.5 0.75 1
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

CONSPIRO & TASQ Force meetings for Air Quality (European Commission)

Thank you very much for your attention!

References

- Schnelle-Kreis, J., Orasche J., Abaszade, G., Schäfer K., Harlos, D. P., Hansen, A. D. A., Zimmermann, R. (2011): Application of direct thermal desorption gas chromatography time-of-flight mass spektrometry for determination of nonpolar organics in low-volume samples from ambient particulate matter and personal samplers, Anal. Bioanal. Chem., 401, 3083-3094
- Orasche J., Schnelle-Kreis, J., Abaszade, G., Zimmermann, R. (2011): Technical Note: In-situ derivatization thermal desorption GC-TOFMS for direct analysis of particle-bound non-polar and polar organic species, Atmospheric Chemistry and Physics, 11, 8977-8993