AirMonTech

Current and future air quality monitoring

T.A.J. Kuhlbusch and AirMonTech Consortium

Rome, 04.12.2012

www.airmontech.eu

- CAFE started 2001 with the aim of improving European air by
  - revising the directives (e.g. PM2.5)
  - national emission ceilings
  - revising traffic emission standards

- Major European research projects on
  Air Quality – Exposure – Health Effects
  (e.g. APHEA 1+2, ESCAPE)

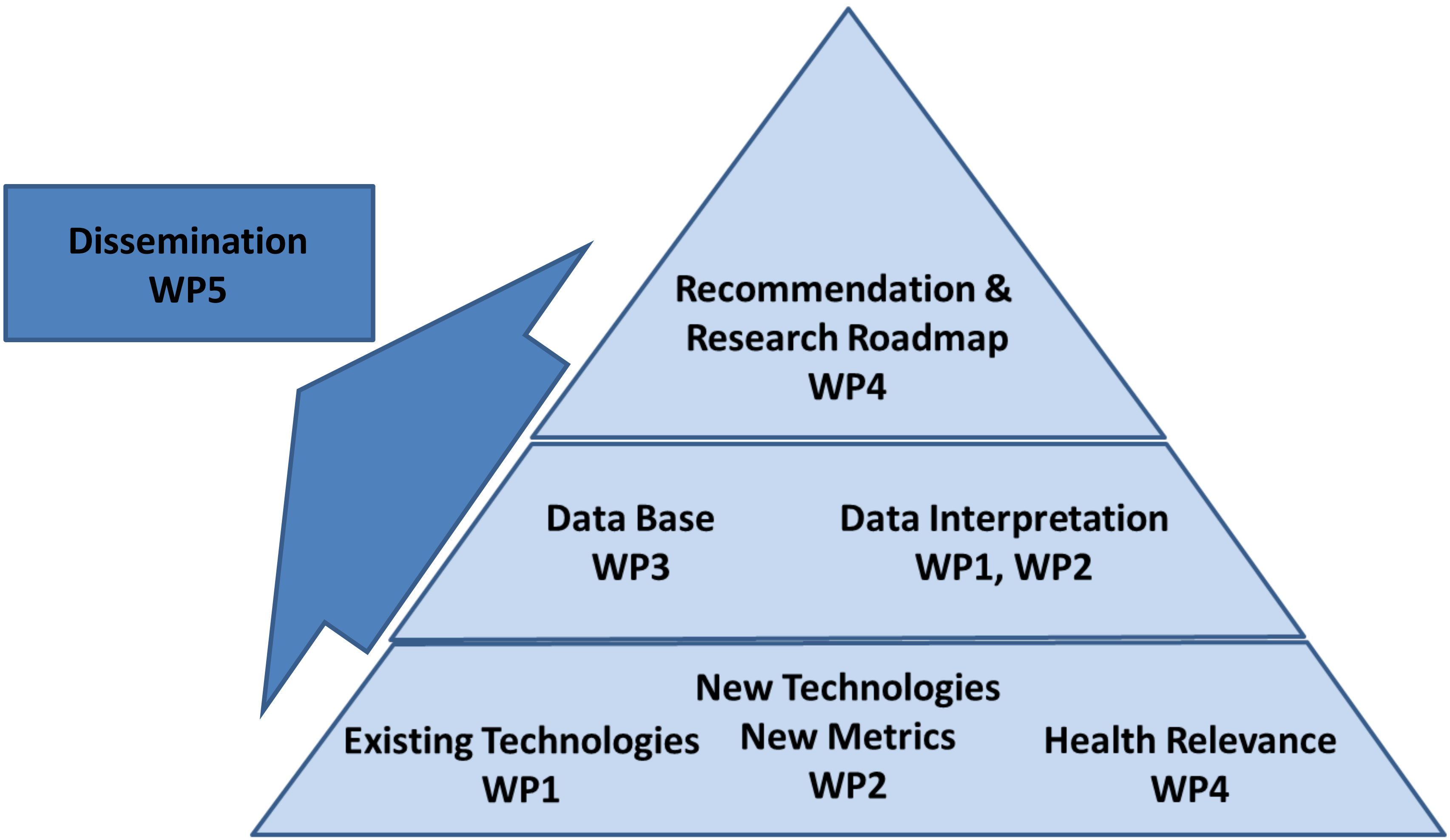
- Major extension of the approach of monitoring air quality with new AQ Directive in 2008 – Average Exposure Index

- Upcoming: Revision of thematic strategy and AQD 2013!
  Horizon 2020!

Aims of AirMonTech

- Facilitating harmonisation and comparability of European air quality monitoring by making information on metrics, techniques and instrumentation available via a database
- Identification of trends and future options in measurement strategies, data quality and comparability
- Discussing and drafting recommendations of future urban air quality monitoring strategies in view of closer linkage to exposure, health effects and assessment of abatement strategies

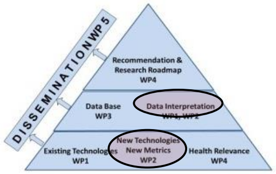
Structure


Dissemination
WP5
Recommendation &
Research Roadmap
WP4
Data Base
WP3
Data Interpretation
WP1, WP2
New Technologies
New Metrics
WP2
Existing Technologies
WP1
Health Relevance
WP4

Air Pollution Monitoring Technologies for Urban Areas

AirMonTech WP2

NEW TECHNOLOGIES – NEW METRICS & PROXIES



Approach:

- Science based reviews of metrics, detection principles and instrument performance
- Collection of manufacturer’s and developer’s information
- Input into the database

Air Pollution Monitoring Technologies for Urban Areas

Metrics in AirMonTech database

- MBI: Metric Basic Information
- MMTO: Metric Measurement Technology Overview
- MMTI: Metric Measurement Technology Information

PM	PM	Gases	Gases
Number concentration	Ammonium	NO	Benzene
Size distribution	Mineral Ions (Ca, Mg, K, Na, Cl)	NO2	VOCs
Surface concentration	Elemental carbon	NOx	PAHs
Shape, morphology	Organic carbon	SO2	Mercury
Mass concentration	Light absorbing aerosols	O3	MultiGasAnalysers
Non-C-elemental composition	Reactive oxygen species	NH3	
Molecular composition	Macrophage mobility decrease	HN	
Mercury	Polycyclic aromatic hydrocarb		
Sulfate	Primary biological	CO	
Nitrate			

http://db-airmontech.jrc.ec.europa.eu/

AirMonTech WP2

Air Pollution Monitoring Technologies for Urban Areas

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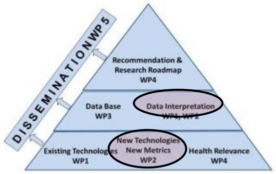


Approach:

- Science based reviews of metrics, detection principles and instrument performance
- Collection of manufacturer’s and developer’s information
- Input into the database
- Evaluation of trends and options

Major trends in instrumentation

- Improved performance by
  - new techniques
  - higher time-resolution

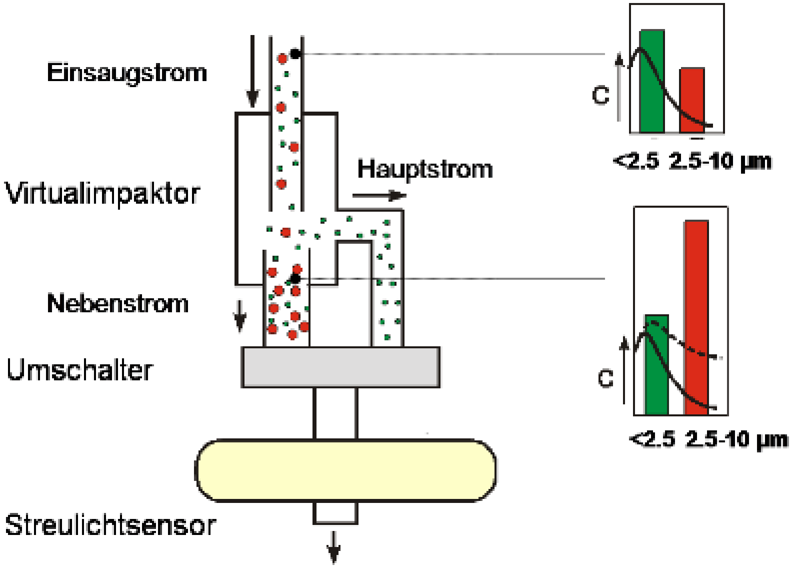
Improved performance: Real-time data

FIDAS (Palas)
PNC, Mass
(PM1, 2.5, 4, 10, TSP)
LED light scattering

SHARP (Thermo)
Mass
Nephelometry + ß-Absorption

EDM 180 (Grimm)
Mass, size distr. 31 ch.
Light Scattering
(Nephelometer)

APM2 (COMDE)
Mass PM2.5/10
Light Scattering
(Nephelometer)



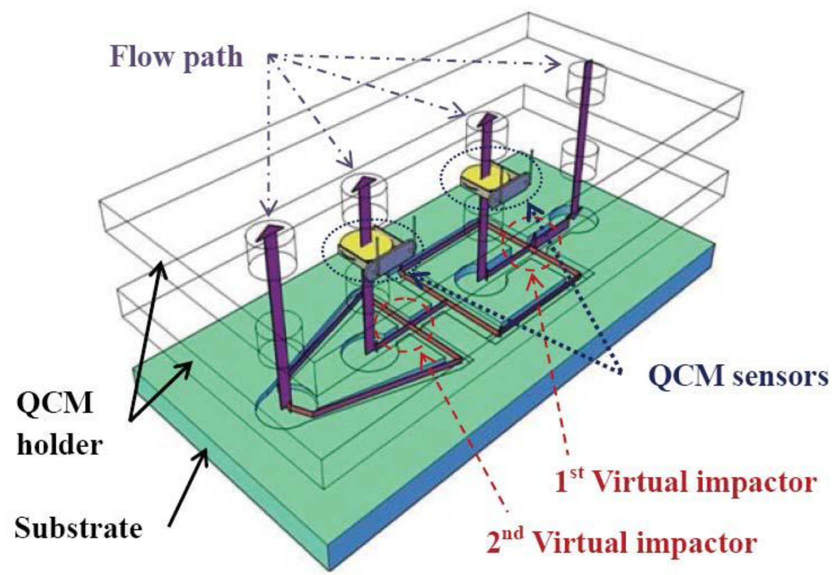
Major trends in instrumentation

- Improved performance by
  - new techniques
  - higher time-resolution
- Miniaturisation
  - Compact monitoring „stations“
  - Handheld detectors and microchip sensors

Miniaturisation

NanoTracer (Philips)
PNC, av. dp

MicroAeth (Magee)
BC in TSP, PM2.5



Quartz Crystal
Microbalance
Sensor
PM mass
Liang et al.
Sensors **2010**:3641-3654

FIDAS mobile (Palas)
PNC, size-distr. (32ch/decade)
0.2-18 µm
PM10/4/2.5/1

DiSCmini (Matter Engineering)
PNC/LDSA(alveo.)
10-300 nm modal

Handheld CPC (TSI)
PNC 10->1000 nm

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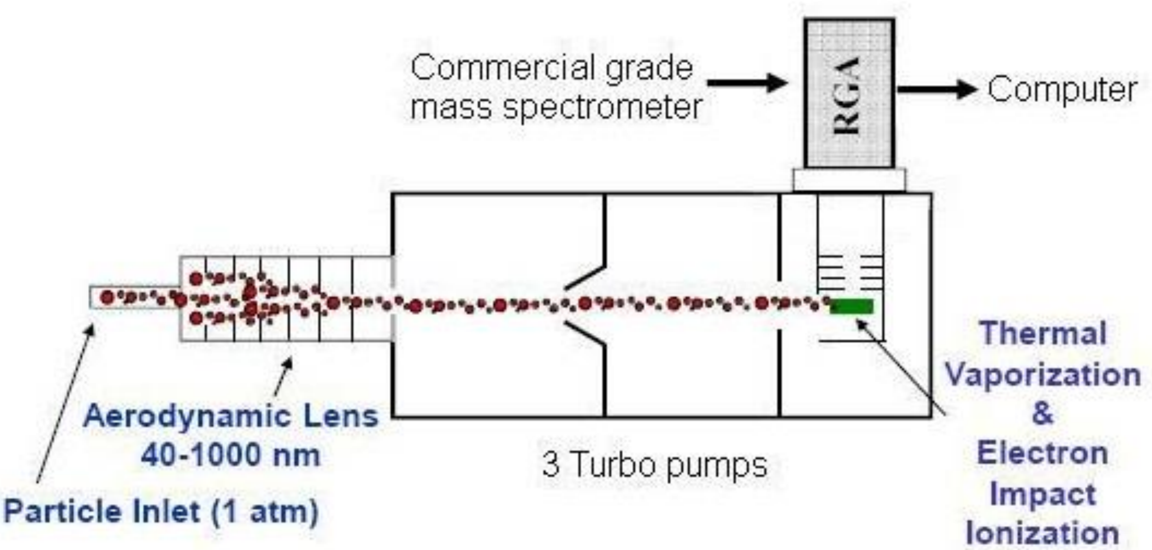
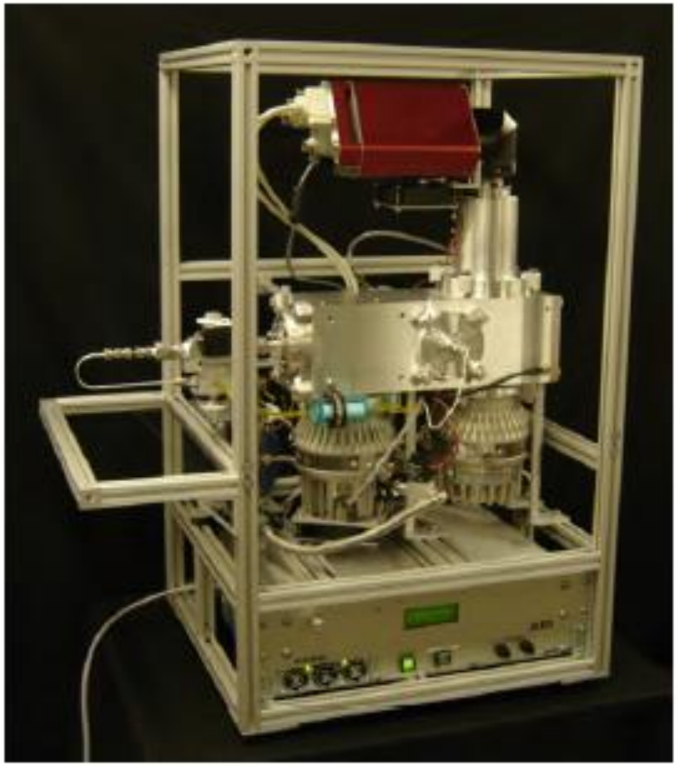
  - for particles (elements, organic matter, solubles) and gases

Multi-component detection 3: ACSM

http://www.aerodyne.com/products/aerosol-chemical-speciation-monitor

http://cires.colorado.edu/~jjose/ams.html





L.N. Ng et al.: Aerosol Science and Technology, Volume 45 (2011) , pp. 770-784(15)

No size data as in AMS, with Quadropole: 0-200 amu range

In development:

ccTOF-ACMS with higher mass range, higher time resolution, higher sensitvity

Example for ACSM field Data:

Y. L. Sun et al., Atmos. Chem. Phys. Discuss., 11, 25751–25784, 2011

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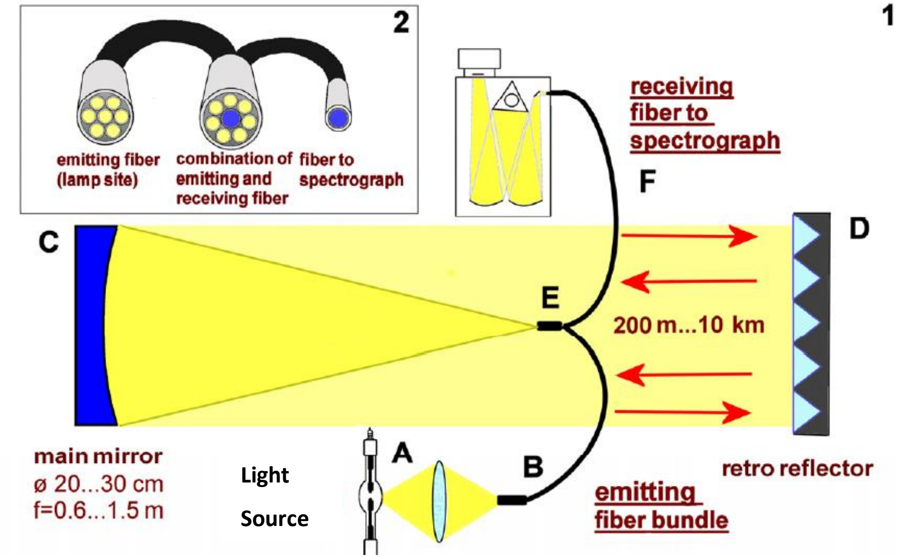
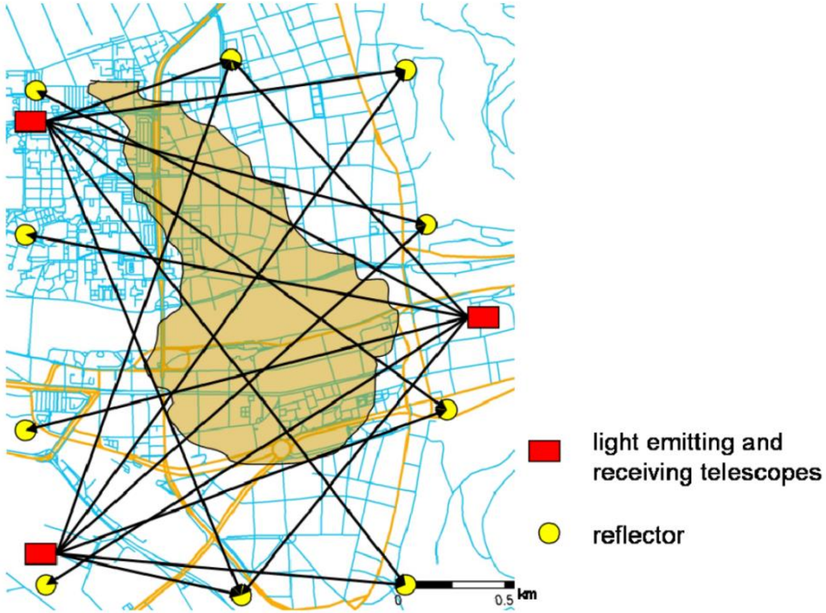
- Open-path monitoring
  - mapping the air quality of a city

Open-Path monitoring

Commercial DOAS (e.g. Opsis, Environnement SA)



New, compact long-path DOAS (Fibre bundles, LEDs)



Tomographic DOAS measurement

Pöhler, D. Dissertation Uni Heidelberg
http://www.ub.uni-heidelberg.de/archiv/10996

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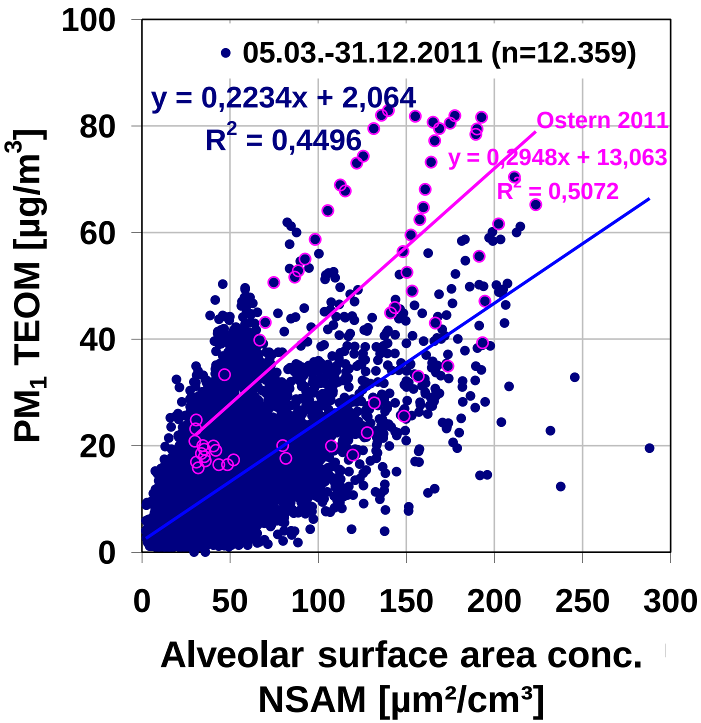
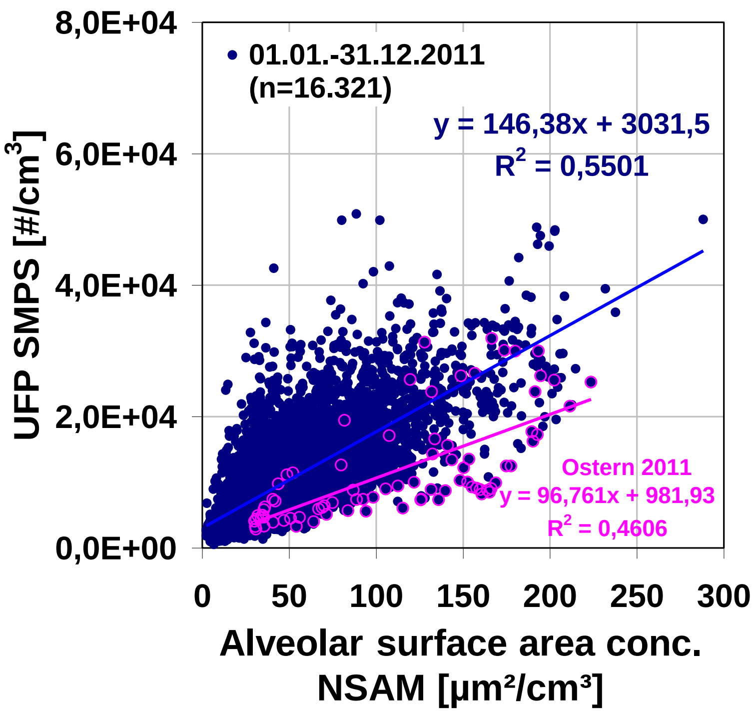
- New chemical-physical metrics

New metrics: Particle Surface

Correlation Surface – PM1



Correlation Surface – UFP



Surface area independent metric to PM1 mass and particle number!

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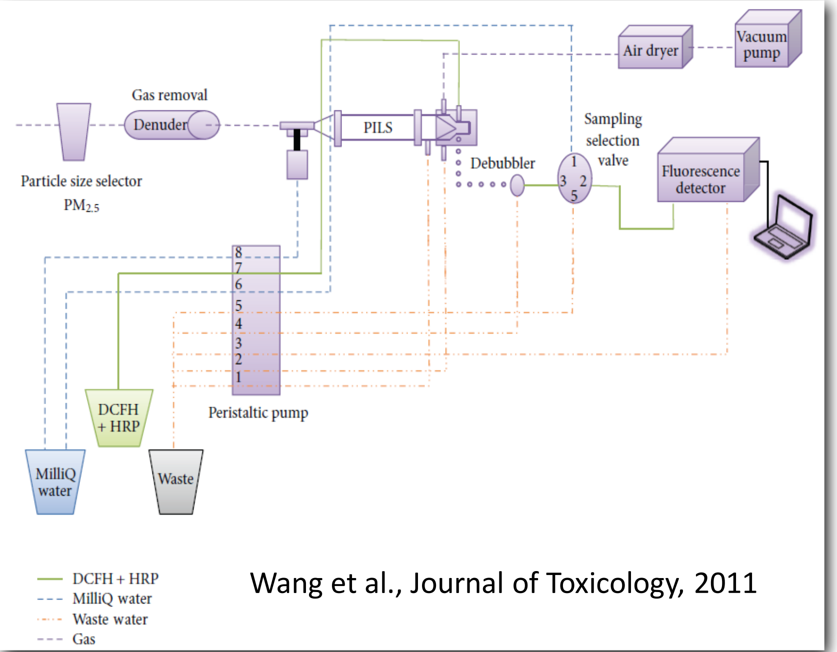
- New chemical-physical metrics
- Health effect related proxies

Health-related proxies: ROS

Particle bound ROS (as H_2O_2 equivalents)



Wang et al., Journal of Toxicology, 2011

Potential for automation of procedure:

O-Radical formation: - DMPO/H_2O_2 spin-trap method (ESR)
- DCFH fluorescence method

Redox Activity: - Dithiothreitol (DTT) consumption assay
- Salicylic acid/ HPLC method

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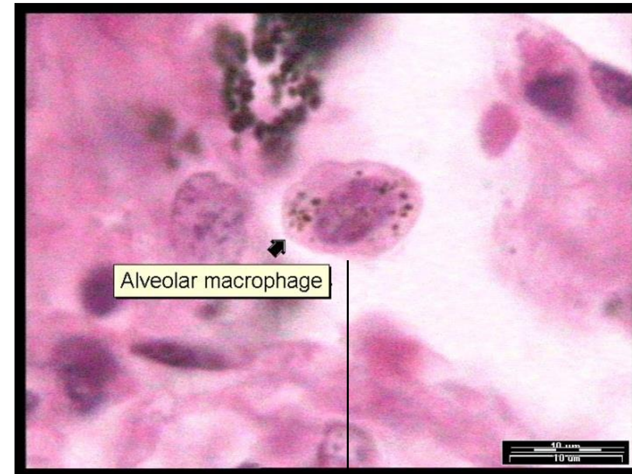
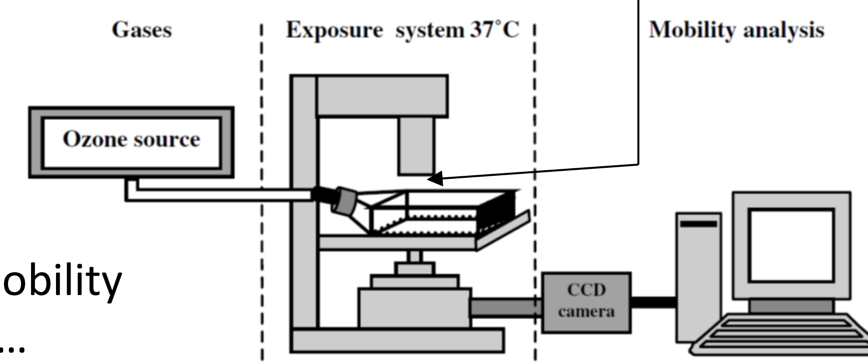
- New chemical-physical metrics
- Health effect related proxies
- On-line in-vitro assays

Biological AQ Monitoring?

Daphnia Magna
for test of
water toxicity





Monitoring of macrophage mobility
while exposed to polluted air…

P. Laval-Gilly et al., J. Pharmacol. Toxicol. Methods, 44:483-488 (2000)
Klestad et al., Toxicology in vitro 2:199–206 (2005)
Environmental biosensor for measuring air contaminants EPO Patent EP1058849

Conclusions 1: Gaseous pollutants

- More sensitive and selective instruments
  → enhance data quality
- Compact stations reduce spatial demands
  → ad-hoc network enlargement
- Devices for not yet regulated compounds (NH_3, VOCs)
- Multicomponent measurements, also open-path
- Microsensors with improved sensitivity and stability
  → option for dynamic sensor networks

Conclusions 2: Particulate pollutants

- Particle counters and sizers
  => help identifying health-relevant fraction
- New metrics (BC, surface) can be monitored directly
  => health studies, source attribution and mitigation control
- On-line elemental and molecular composition measurement possible
  => source identification and apportionment
- Automated monitoring of bioallergens
  => input as confounders in epi studies?

In summary…

Monitoring technology provides a multitude of options to

- improve,
- widen,
- re-direct
- re-consider

air pollution monitoring strategies.

the goal is reduction of public health effects!

→ Research needs

Air Pollution Monitoring Technologies for Urban Areas

Research road map

National Physical Laboratory

WPs 1, 2 and 3

monitoring technologies

health effects

linkages between pollutants

recommendations for regulatory monitoring

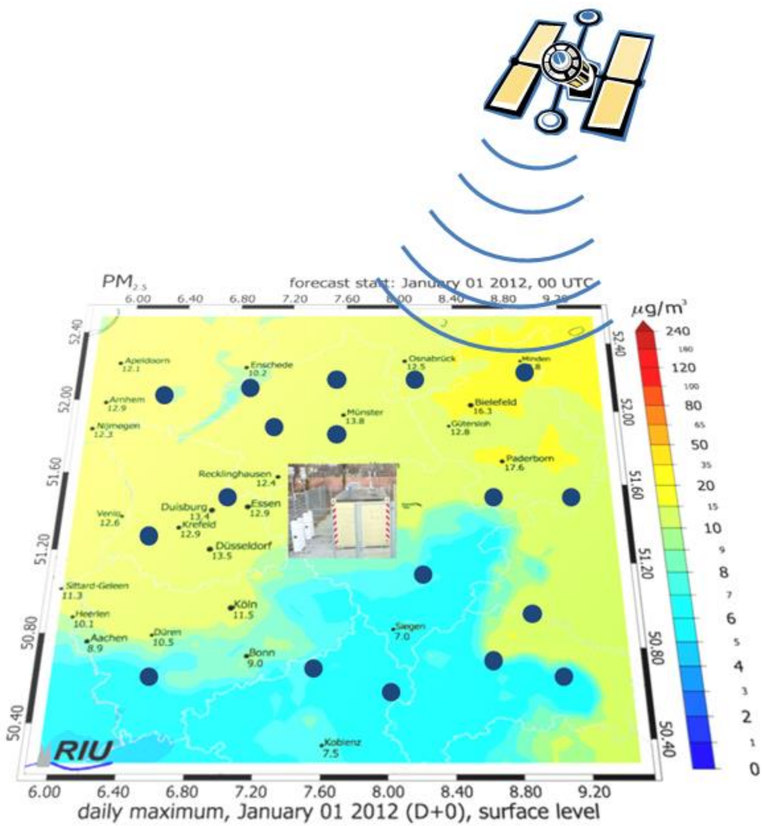
other monitoring

network aims

WP 4

Air Pollution Monitoring Technologies for Urban Areas

Future strategy



Visualisation of a future monitoring concept linking all available monitoring tools, fixed site measurements, mobile and flexible measurements, modelling and satellite observations.

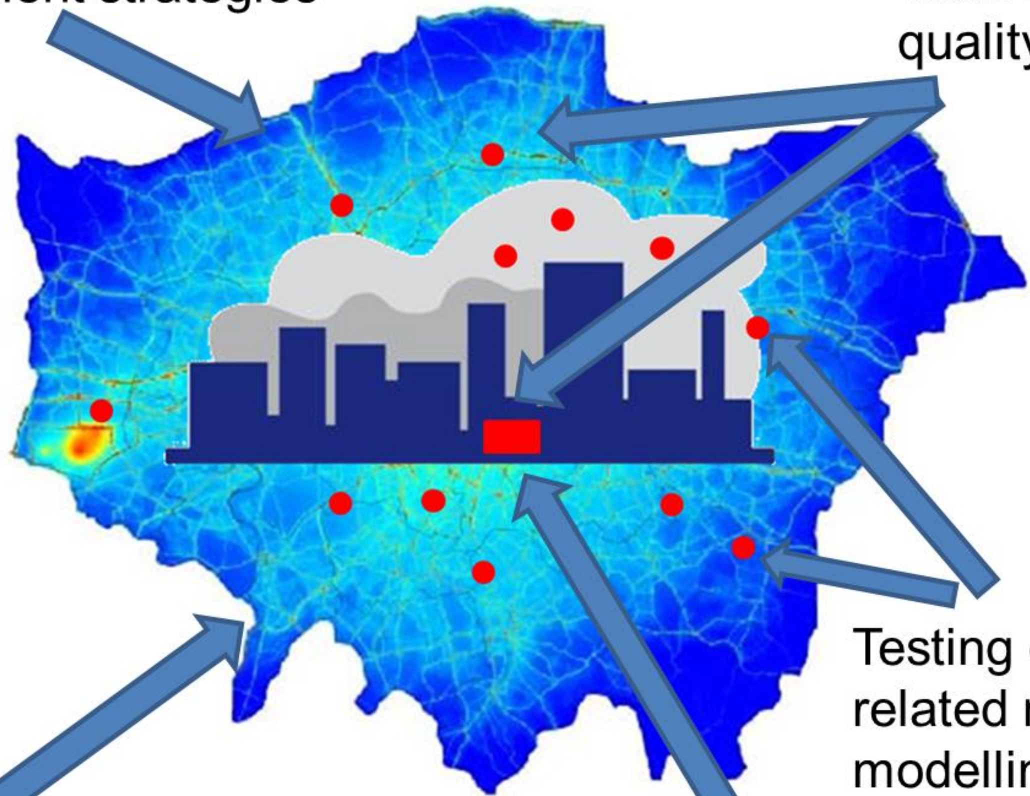
Kuhlbusch et al. 2013

Air Pollution Monitoring Technologies for Urban Areas

Urban AQ Monitoring Tasks

Assessment of abatement strategies

Testing new air quality parameters



Testing different exposure related monitoring and modelling concepts

Regularly linking air quality data to health information

Current fixed air quality monitoring sites

Kuhlbusch et al. 2013

In summary…

Major **remaining challenges** and corresponding research needs are identified, comprising e. g.

- ✓ Facilitation of the use of in-situ open-path and remote sensing instruments for urban air quality assessment
- ✓ Lowering detection limits and reliability of chip-size microsensors for health relevant gases as well as development of microsensors for particle mass and/or chemical compounds
- ✓ Development of methods that allow to better describe particle morphologies for improved discrimination of particle sources
- ✓ Lack of exposure data for many particle characteristics to identify those “silver bullets” that might be given priority in future air quality control.
- ✓ …….

Joint
AirMonTech – EuNetAir
workshop
Duisburg, 4-6 March 2013

Air Pollution Monitoring Technologies for Urban Areas

iuta

Tentative Schedule

	Tentative Time	Block Topics
March 4	10-12	Measurement techniques & Monitoring Devices
	13-15	Air Quality Modelling with regard to Urban Environment
	15-17	Current regulatory approach…linking different approaches
March 5	9-11	Linking AQ monitoring to epidemiology/health effects monitoring
	11-13	Research Roadmap for next 10 Years
	14-17	COST EuNetAir Session "Environmental Case Studies from Central and Eastern Europe"
March 6	9-15	COST EuNetAirWG3/WG 4 Meeting

Air Pollution Monitoring Technologies for Urban Areas

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The AirMonTech team
www.airmontech.eu

Thanks for your attention!

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