Challenges and the Future of Urban Air Quality Monitoring in Europe

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Air Quality & Sustainable Nanotechnology

Frontiers in Air Quality Science,
21 years of the Environmental Research Group
London, 23rd of June 2014

UNIVERSITÄT DUISBURG ESSEN

Air quality deteriorating in many of the world's cities

News release

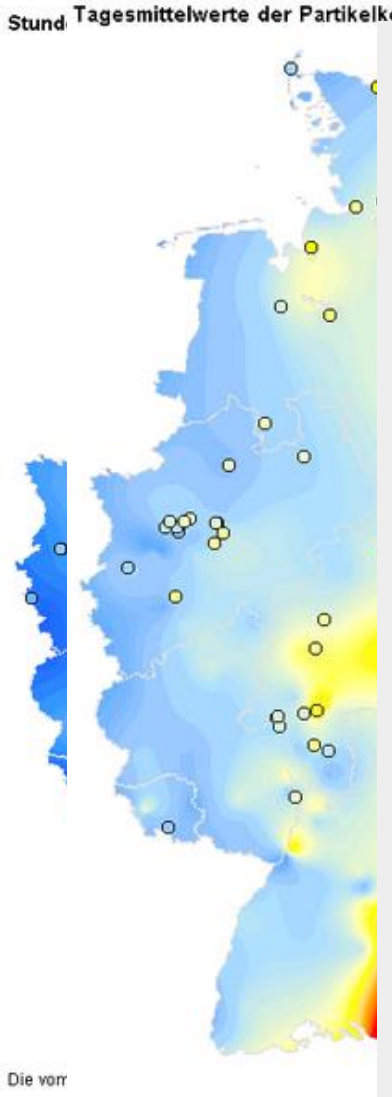
7 May 2014 | *GENEVA* - Air quality in most cities worldwide that monitor outdoor (ambient) air pollution fails to meet WHO guidelines for safe levels, putting people at additional risk of respiratory disease and other health problems.

……

In most cities where there is enough data to compare the situation today with previous years, air pollution is getting worse. Many factors contribute to this increase, including reliance on fossil fuels such as coal fired power plants, dependence on private transport motor vehicles, inefficient use of energy in buildings, and the use of biomass for cooking and heating.

But some cities are making **notable improvements** - demonstrating that air quality can be improved by implementing policy measures such as banning the use of coal for "space heating" in buildings, using renewable or "clean" fuels for electricity production, and improving efficiency of motor vehicle engines.

Urban Air Quality 2014



Stationscode	Stationsname	Tagesmittelwerte über 50 µg/m³	Messmethode	Erster Messtag im Jahr	Aktuellster im Jahr
DEBW118	Stuttgart Am Neckartor (S)	51	G	01.01.2014	13.05.2014
DEBE063	B Neukölln-Silbersteinstr.	35	K	01.01.2014	20.06.2014
DESN077	Leipzig Lützner Str. 36	34	K	01.01.2014	20.06.2014
DEST102	Halle/Paracelsusstr.	33	K	01.01.2014	20.06.2014
DEBB045	Frankfurt (Oder), Leipziger Str.	32	K	01.01.2014	20.06.2014
DESN083	Chemnitz-Leipziger Str.	32	K	01.01.2014	20.06.2014
DEBE065	B Friedrichshain-Frankfurter Allee	31	K	01.01.2014	20.06.2014
DEBE064	B Neukölln-Karl-Marx-Str. 76	30	K	01.01.2014	20.06.2014
DESN025	Leipzig-Mitte	30	K	01.01.2014	20.06.2014
DESN084	Dresden-Bergstr.	30	K	01.01.2014	20.06.2014

Ambient (outdoor) air quality and health

Key facts: Fact sheet N°313, Updated March 2014

- Air pollution is a major environmental risk to health. By reducing air pollution levels, countries can reduce the burden of disease from stroke, heart disease, lung cancer, and both chronic and acute respiratory diseases, including asthma.
- The lower the levels of air pollution, the better the cardiovascular and respiratory health of the population will be, both long- and short-term.
- The "WHO Air quality guidelines" provide an assessment of health effects of air pollution and thresholds for health-harmful pollution levels.
- Ambient (outdoor air pollution) in both cities and rural areas was estimated to cause 3.7 million premature deaths worldwide in 2012.
- Policies and investments supporting cleaner transport, power generation, industry …would reduce key sources of urban outdoor air pollution.
- Reducing outdoor emissions from household coal and biomass energy systems, …would reduce key rural and peri-urban air pollution sources……..
- Reducing outdoor air pollution also reduces emissions of CO_2 and short-lived climate pollutants .., thus contributing to the … mitigation of climate change.

So what are the challenges for urban air quality for the years to come?

Challenge 1: “Old” metrics

- Limit value attainment
- Lower limit values?
- Artefacts
- New methods
- Temporal and spatial information
- Sensor technologies
- Mobile monitoring

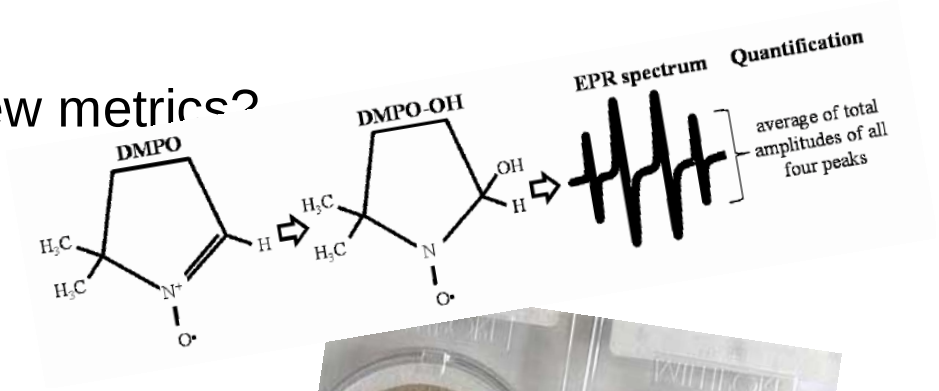
➔ Higher time and spatial (horizontal and sometime vertical) resolution

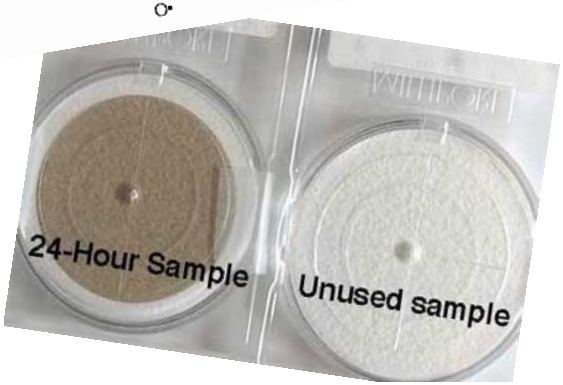
➔ Challenge for measurement devices, data integration and interpretation

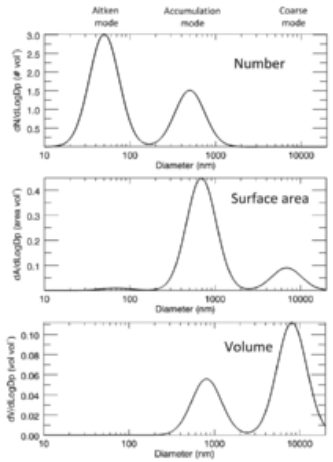
Challenge 2: “New” metrics

What is needed for / to implement new metrics?

- The new metric!
- Definition of the metric
- Measurement techniques
- Data availability and quality
- Independency of other pollutant metrics
- Health effect studies
- Linkage to emission
- International standards







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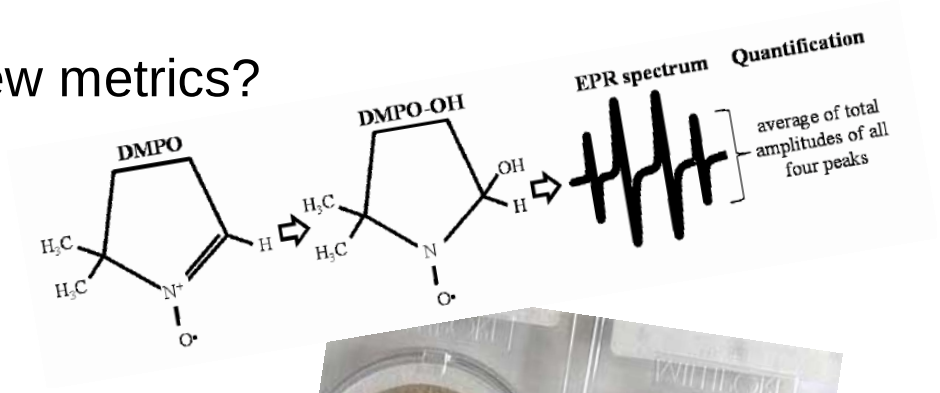
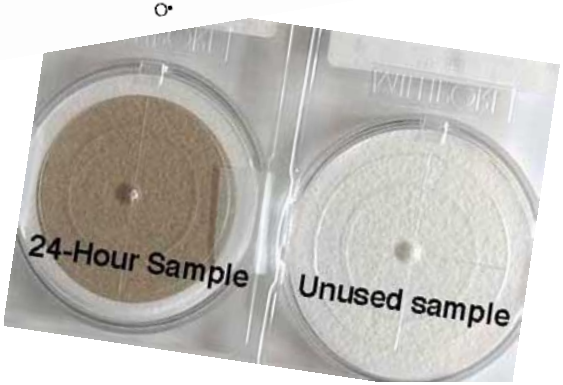
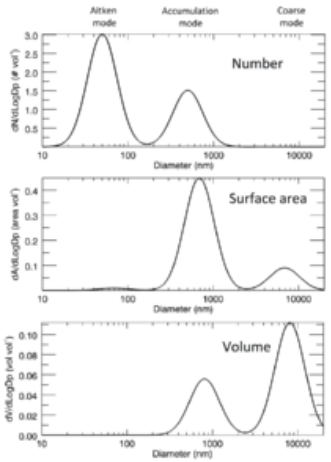






➔ e. g. ROS developments in all the above areas

Hellack et al. (2014)

a) A comparison ROS detection methods for ambient PM collected on Polytetrafluoroethylene and quartz fibre filters showed that an adapted method for PM elicit ROS measurements on quartz fibre filters, commonly used in routine monitoring networks is applicable.

b) The identification of suitable materials for method standardisation enabling intra- and inter-laboratory comparability is discussed.

Janssen et al. (2014)

Contrasts in OP between sites, differences in size fractions and correlation with PMcomposition depended on the specific OP assay used….

This suggests that either OP_{ESR} or OP_{AA} and OP_{DTT} can complement each other in providing information regarding the oxidative properties of PM, which can subsequently be used to study its health effects.

Yang et al. (submitted)

OP^{ESR} correlated poorly with $PM_{2.5}$ mass both spatially (Spearman’s r_s = 0.29) and temporally (median r_s = 0.34). The day-to-day correlations across sites for OP^{ESR} were moderate (r_s = 0.29-0.75) compared to $PM_{2.5}$ (r_s = 0.70-0.96). Street/urban background and street/regional background ratios for OP^{ESR} were 1.4 and 2.4 times respectively; higher than for $PM_{2.5}$ (ratio of 1.1).

Health effects

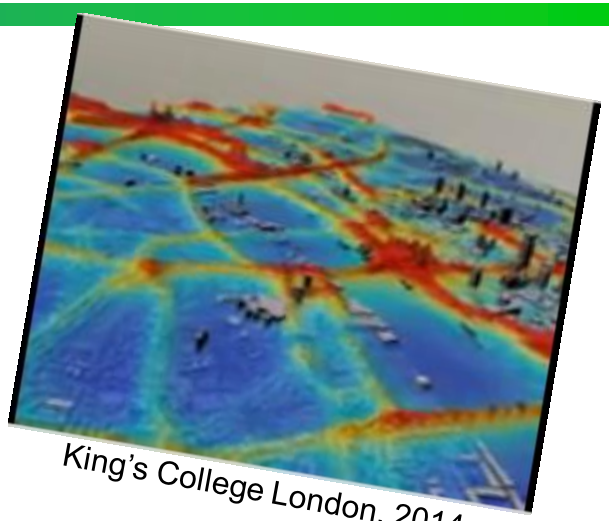
Toxicological link between ROS and effects (e.g. Donaldson et al. 2003, Schins et al. 2004, Wessels et al. 2010)

Mixed results in epidemiology low correlations to short term effects (e.g. Janssen et al, submitted), sometimes indication of long term effects, e.g Shi et al. 2003, Hellack et al. for diabetes II (in prep.)….

What is needed?

Challenge 3: Modelling

- Spatial and temporal resolution
- Metrics: What can be modelled?
- Verification
- How can the data quality be assessed?
- Linkage of FAIRMODE and CEN TC 264



King's College London, 2014

➔ Higher spatial and temporal resolution measurements for the assessment of models?

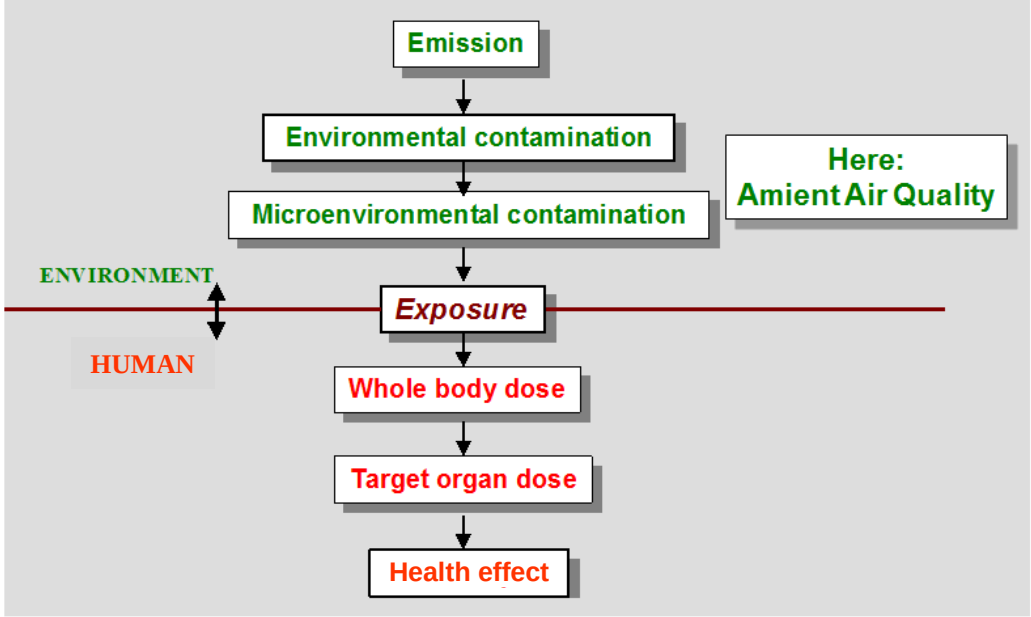
➔ A tool to integrate measurement data?

➔ A tool for exposure assessment?

Nesting regional and local scale models
King's combined local scale (ADMS) and regional scale (CMAQ) models to produce a model (CMAQ-urban Beevers et al., 2012) that is capable of modelling (hourly) all of Europe's emissions and detailed enough to provide concentrations at 20m intervals in urban areas, where it's needed most.
CMAQ-urban is therefore able to assess air quality policy at European scales all the way down to changes on single roads.

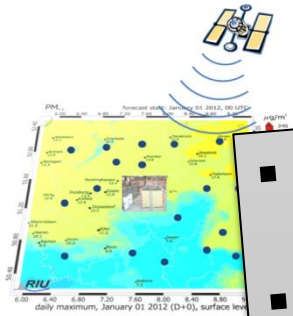
Challenge 4: Exposure

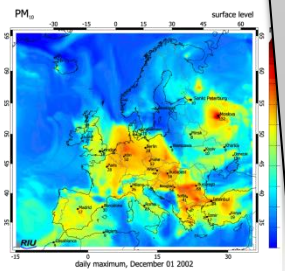
- Population exposure (implementation – other metrics)
- Personal exposure (research to regulation?)
- Public places and buildings
- How effective is the regulation of ambient air with improved air quality? Become other exposure locations be more important for personal health?

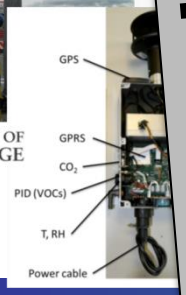


adapted from Matti Jantunen

Challenge 5: Data integration and exploitation







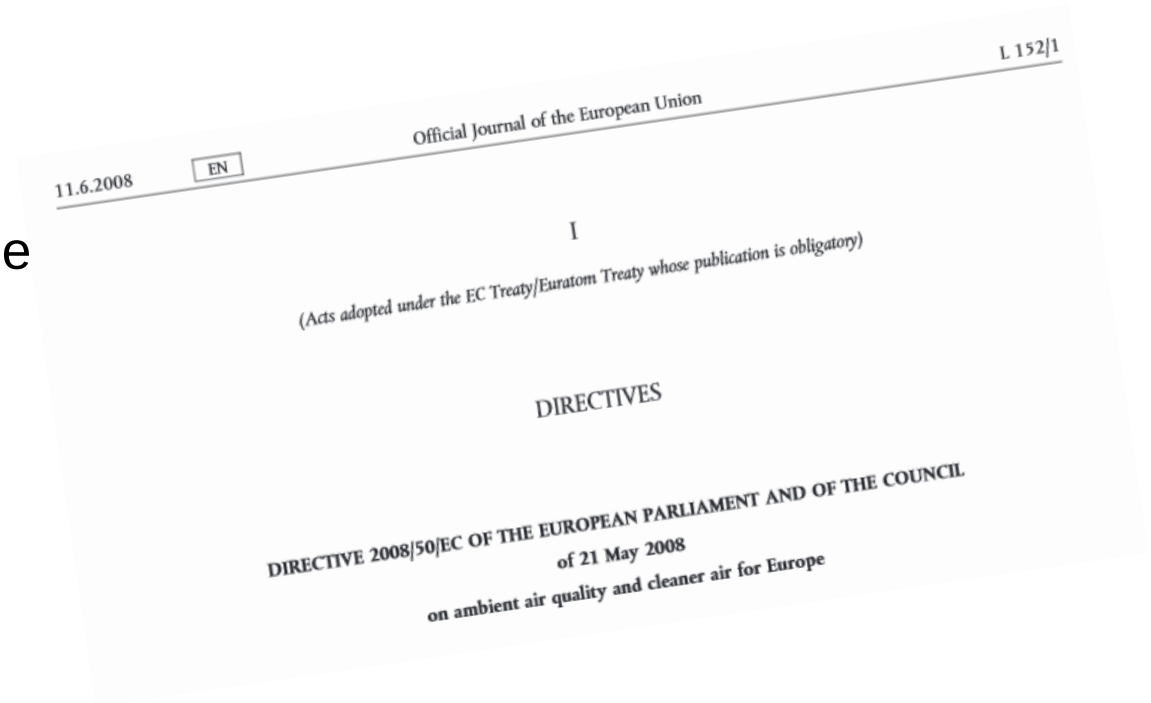
UNIVERSITY OF CAMBRIDGE
Sensor Network at Heathrow Airport

- Integrating model and measured data
- Concentration maps construed using modelled and measured data
- Improve spatial-temporal information
- Routine trend analysis
- Exposure assessment
- Data for source apportionment
- Information of the public
- ……

Resch et al., 2011

Challenge 6: Regulation and Air Quality Monitoring

- Fixed monitoring sites
- Limit values
- Population exposure index (other pollutants?)
- Emission to ambient air quality
- City planning
- Action planning
- Adaptation to multipurpose AQ monitoring?



Challenge 7: Abatement Strategies

Assessment of effectiveness of

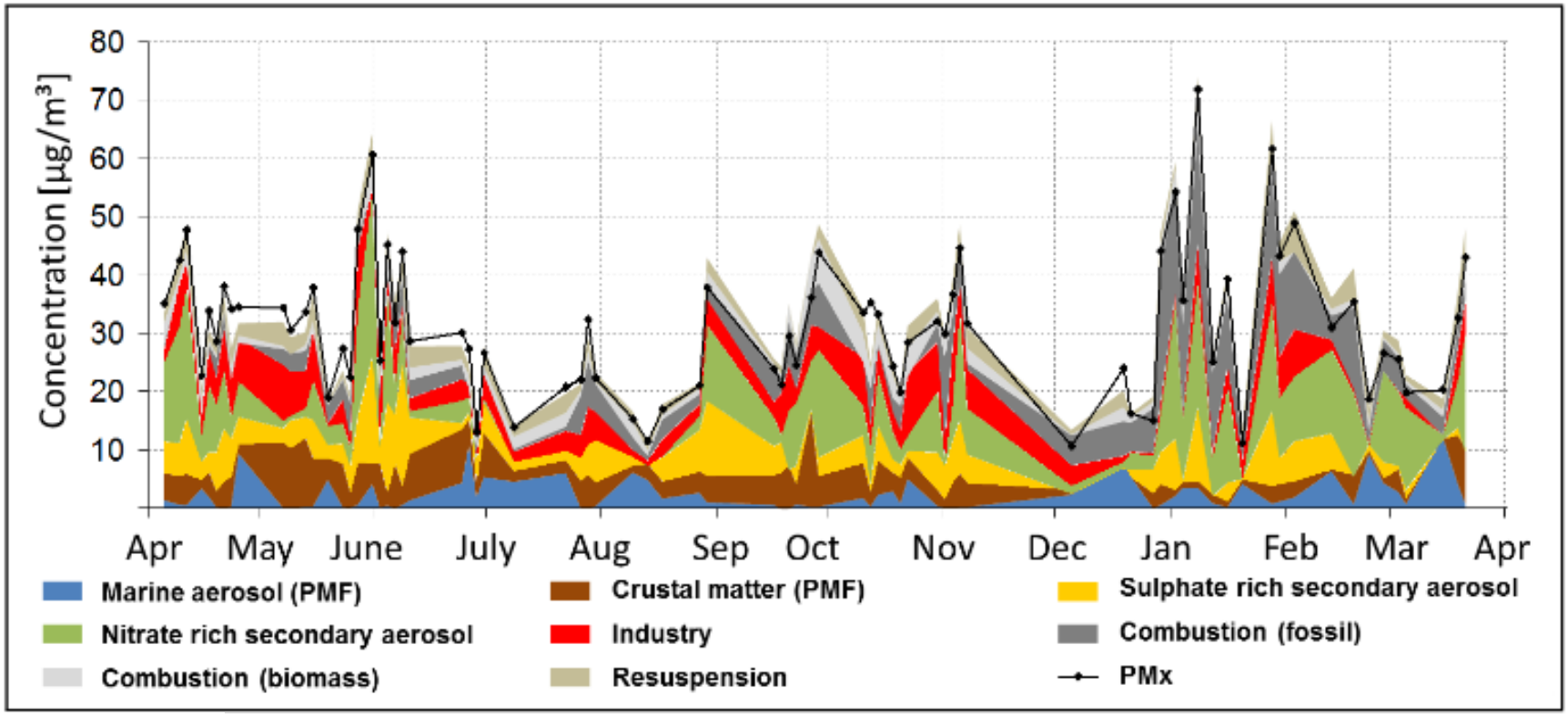
- Low emission zones
- Street cleaning
- Biomass burning actions

…

insight.nhtv.nl

kingscrossenvironment.com

Online source apportionment for decisions on effective measures?



Time series of a PMF study related to an urban background site (Beuck, 2010)

Challenge 8: Source apportionment

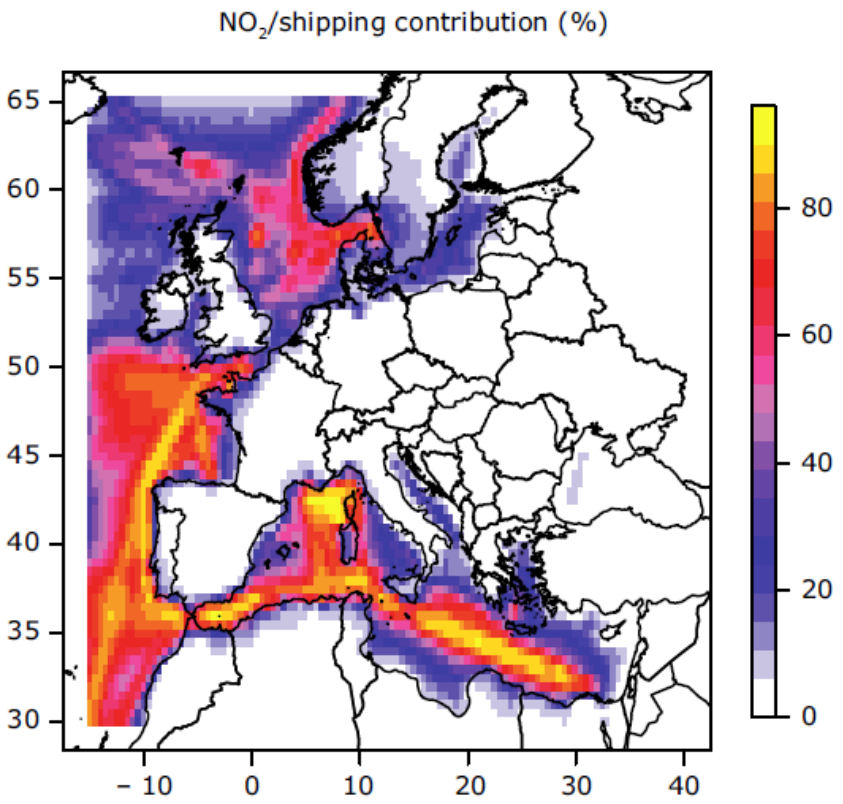
Online source apportionment for decisions on effective measures

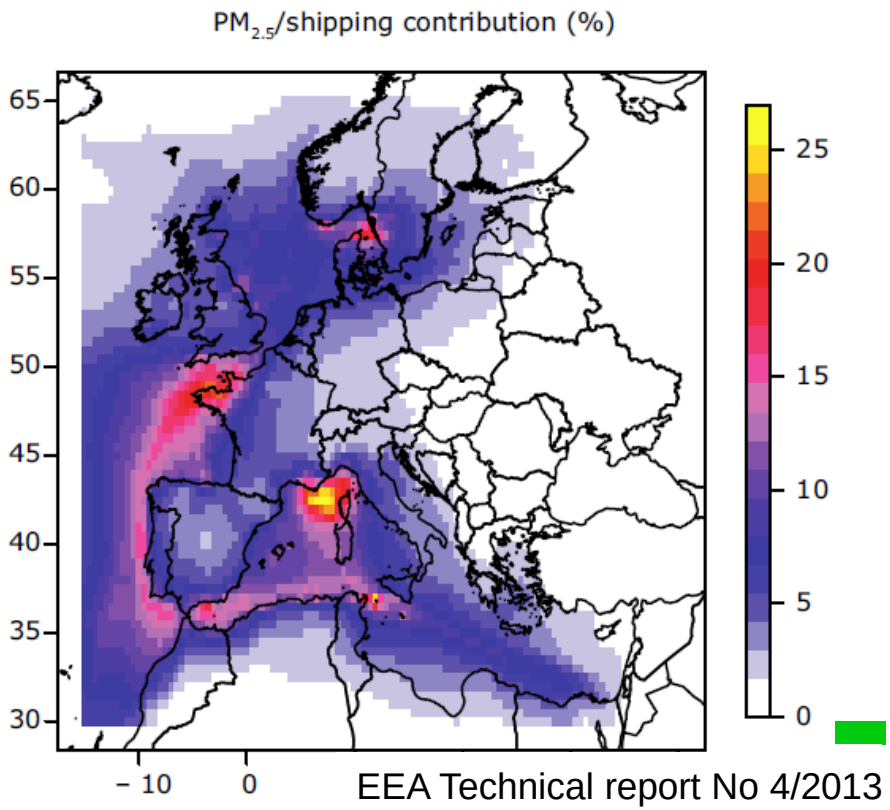
Routine Lenschow Approach

Emission inventory

Source selective modelling (ENERGEO, M. Schaap)

Figure ES.2 Relative contribution of international shipping emissions (in %) on annual mean NO_2 and $PM_{2.5}$ concentrations in the year 2005

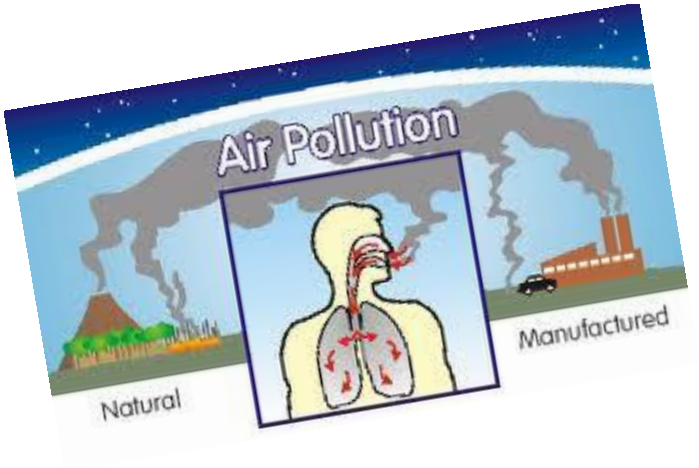


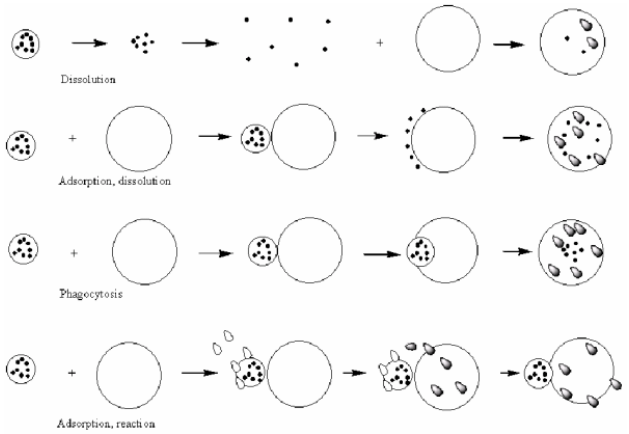


EEA Technical report No 4/2013

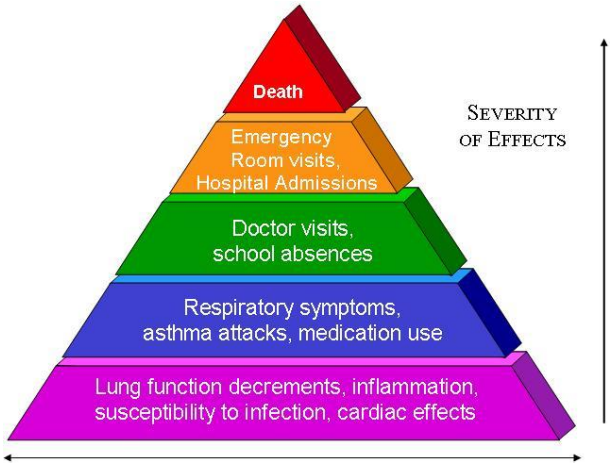
Challenges

- exposure assessment
- uptake
- new metrics and health
- short term - long term effects
- toxicity (biokinetic - mode of action – reversibility)





Nel et al. 2001 (EPA)

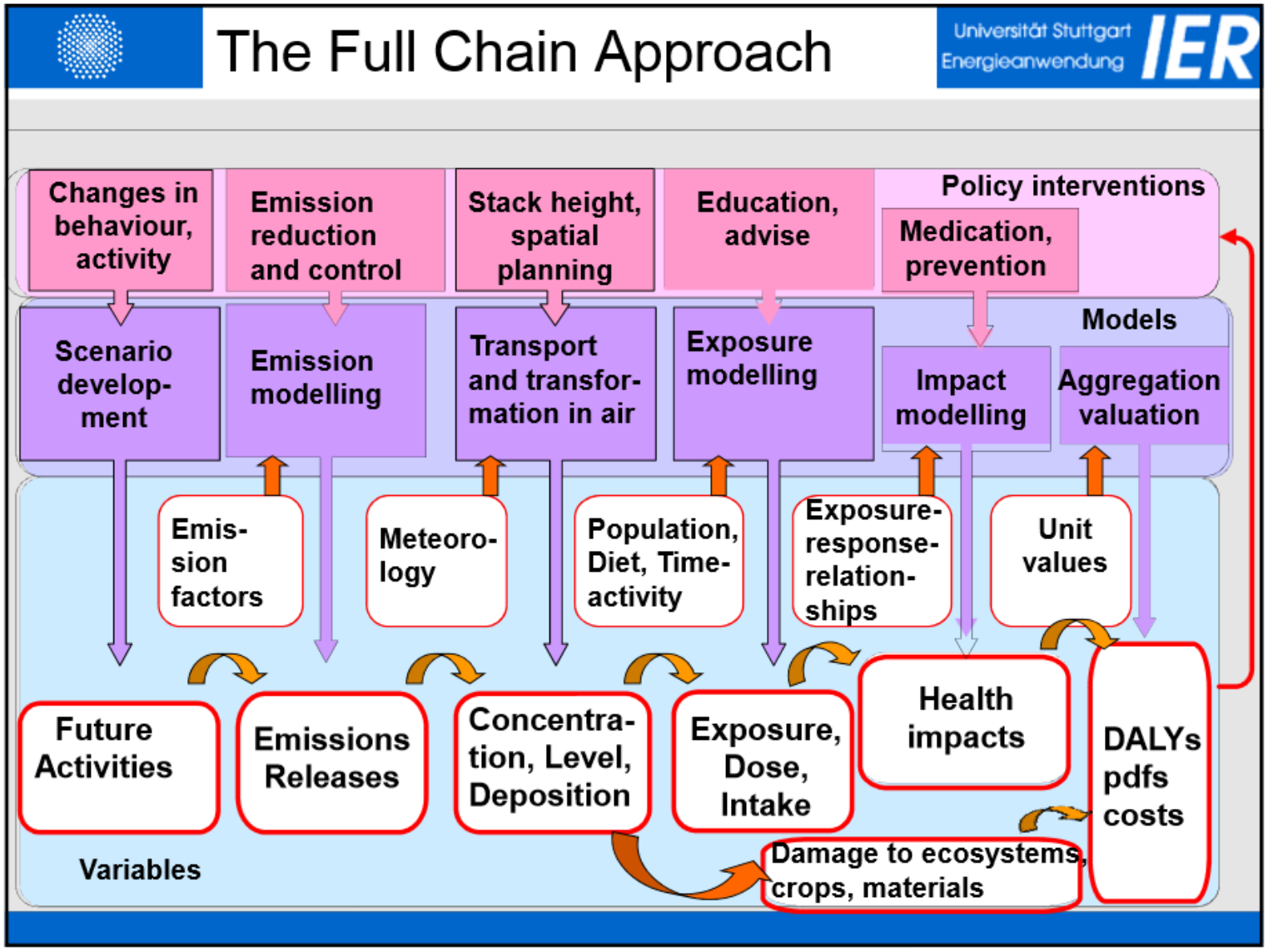


Challenge 10: Health effect monitoring

- Routine monitoring of health data to allow for health effect assessments and assessment of the effectiveness of the AQ measures
- How can the routine data sets be used for health effect monitoring?
- Routine health effect assessment using time series studies?
- Routine health effect assessment using cohort studies?
- Which health endpoints?

Do all the abatement measures really improve the public health and quality of life?

Is there a return of investment?

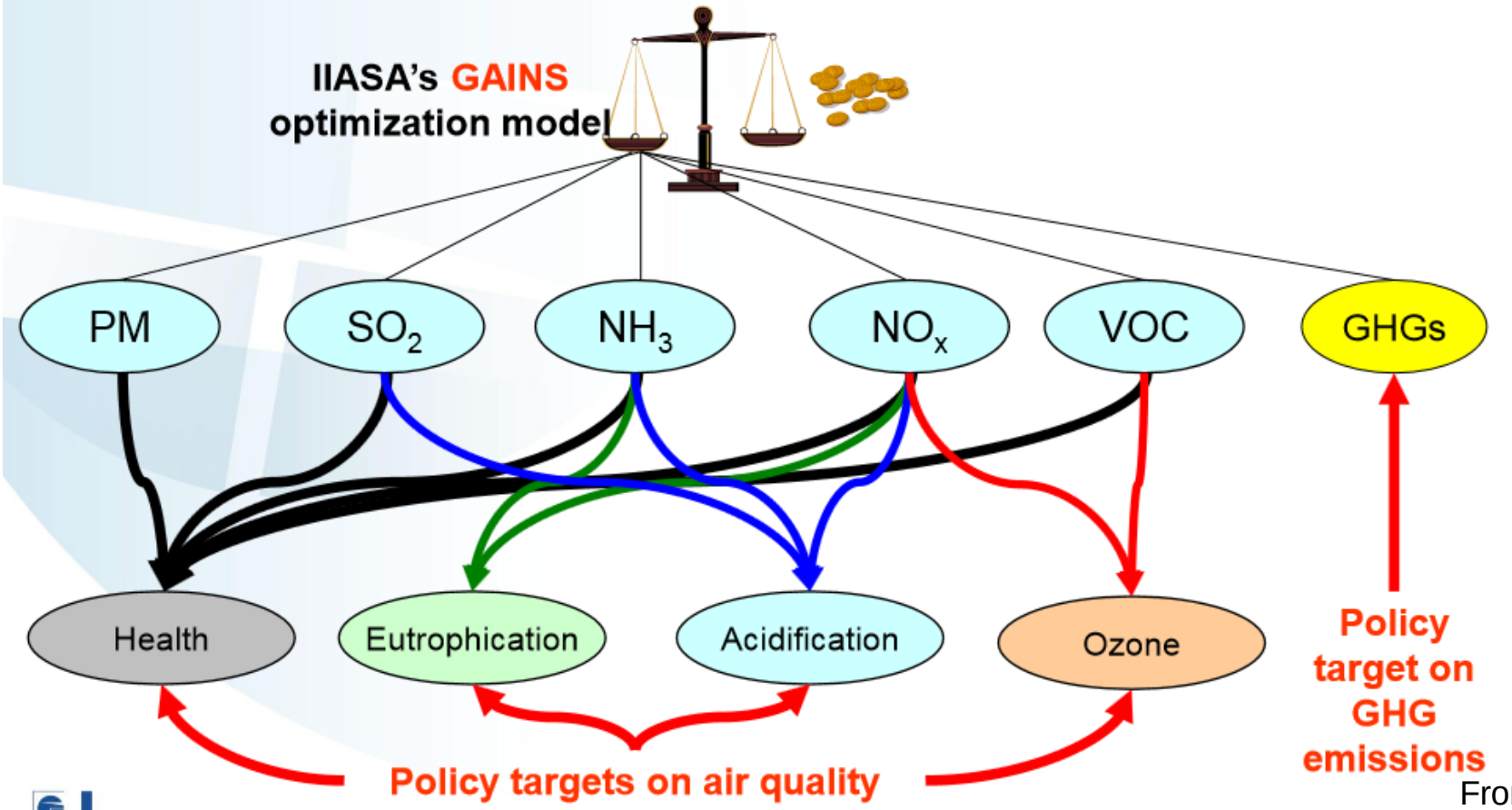


From R. Friedrich - IER Stuttgart

The GAINS approach

for identifying cost-effective emission control strategies

(GHG-Air pollution INteractions and Synergies)



From Z.Klimont - IIASA

Extension of the GAINS multi-pollutant/multi-effect framework to include near-term climate impacts (http://gains.iiasa.ac.at)

	PM (BC, OC)	SO_2	NO_x	VOC	NH_3	CO	CO_2	CH_4	N_2O	HFCs PFCs SF_6
Health impacts: PM (Loss in life expectancy)	√	√	√	√	√					
O_3 (Premature mortality)			√	√		√		√		
Vegetation damage: O_3 (AOT40/fluxes)			√	√		√		√		
Acidification (Excess of critical loads)		√	√		√					
Eutrophication (Excess of critical loads)			√		√					
Climate impacts: Long-term (GWP100)							√	√	√	√
Near-term forcing (in Europe and global mean forcing)	√	√	√	√	√	√				
Black carbon deposition to the arctic	√									

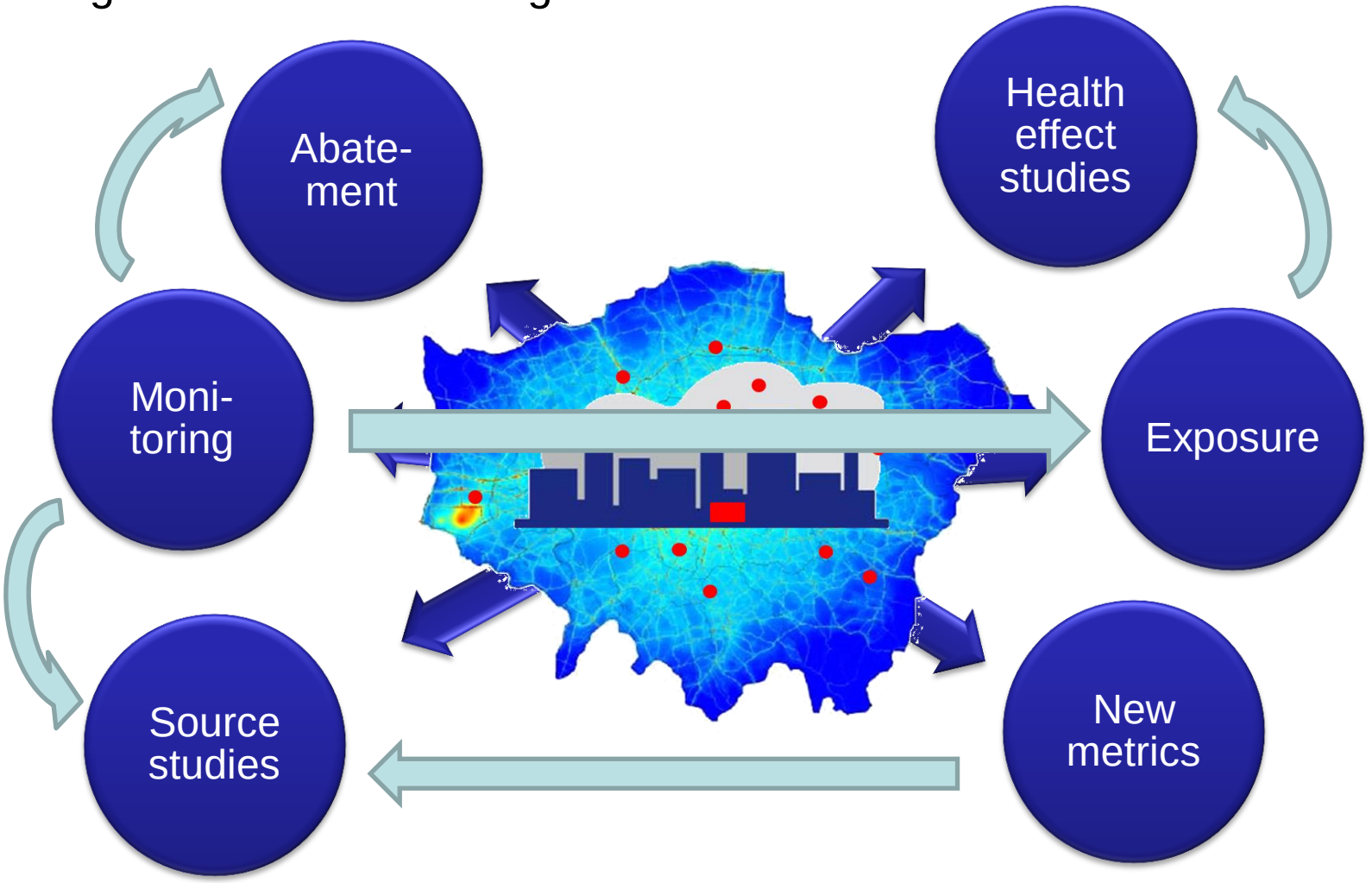
From Z.Klimont - IIASA

Challenge 12: Communication

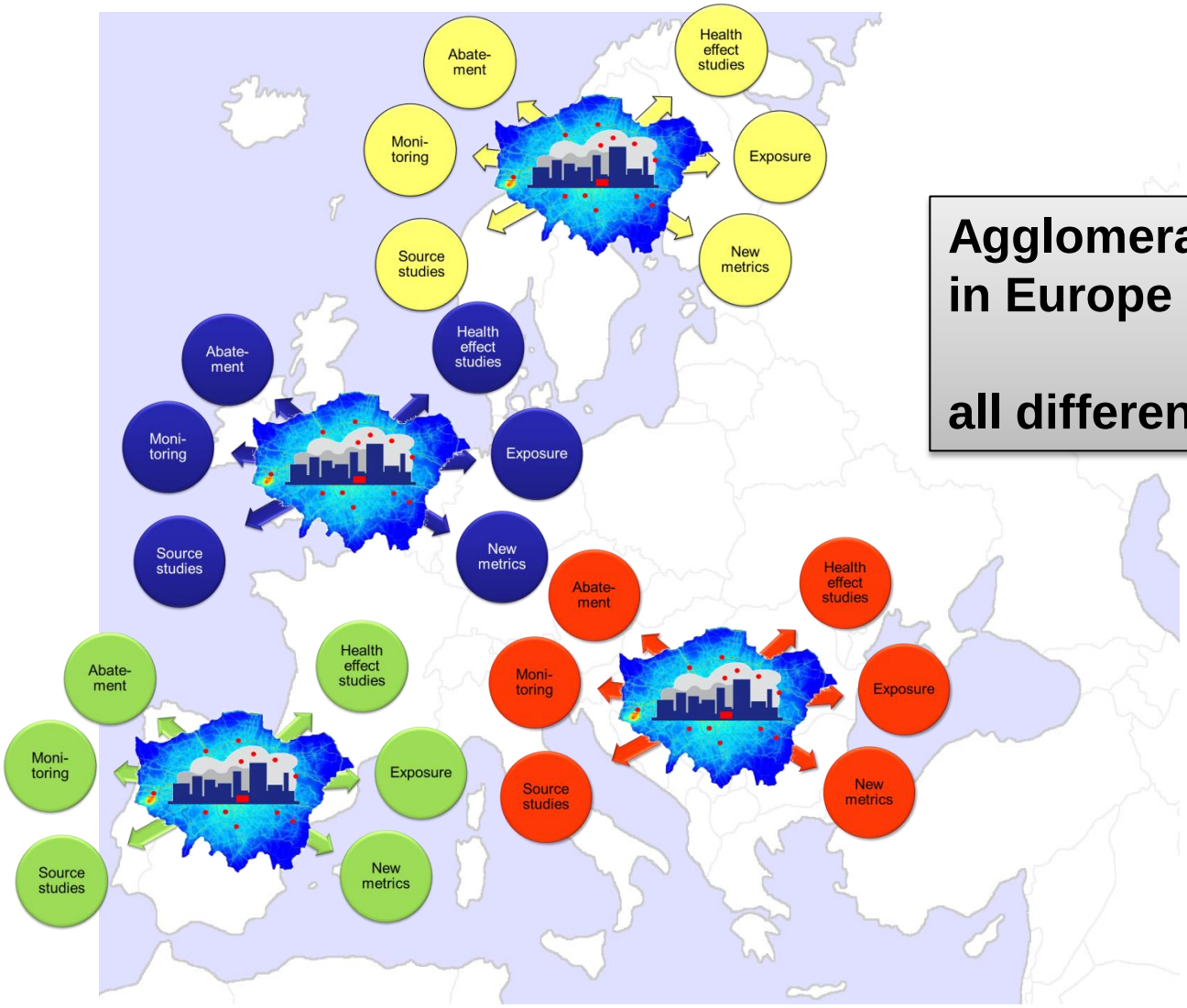
European wide

- to the public
- to public bodies, incl. EC
- between the researchers
- between public bodies
- between researchers, public bodies, SME & Industry

Linking the different challenges and tasks



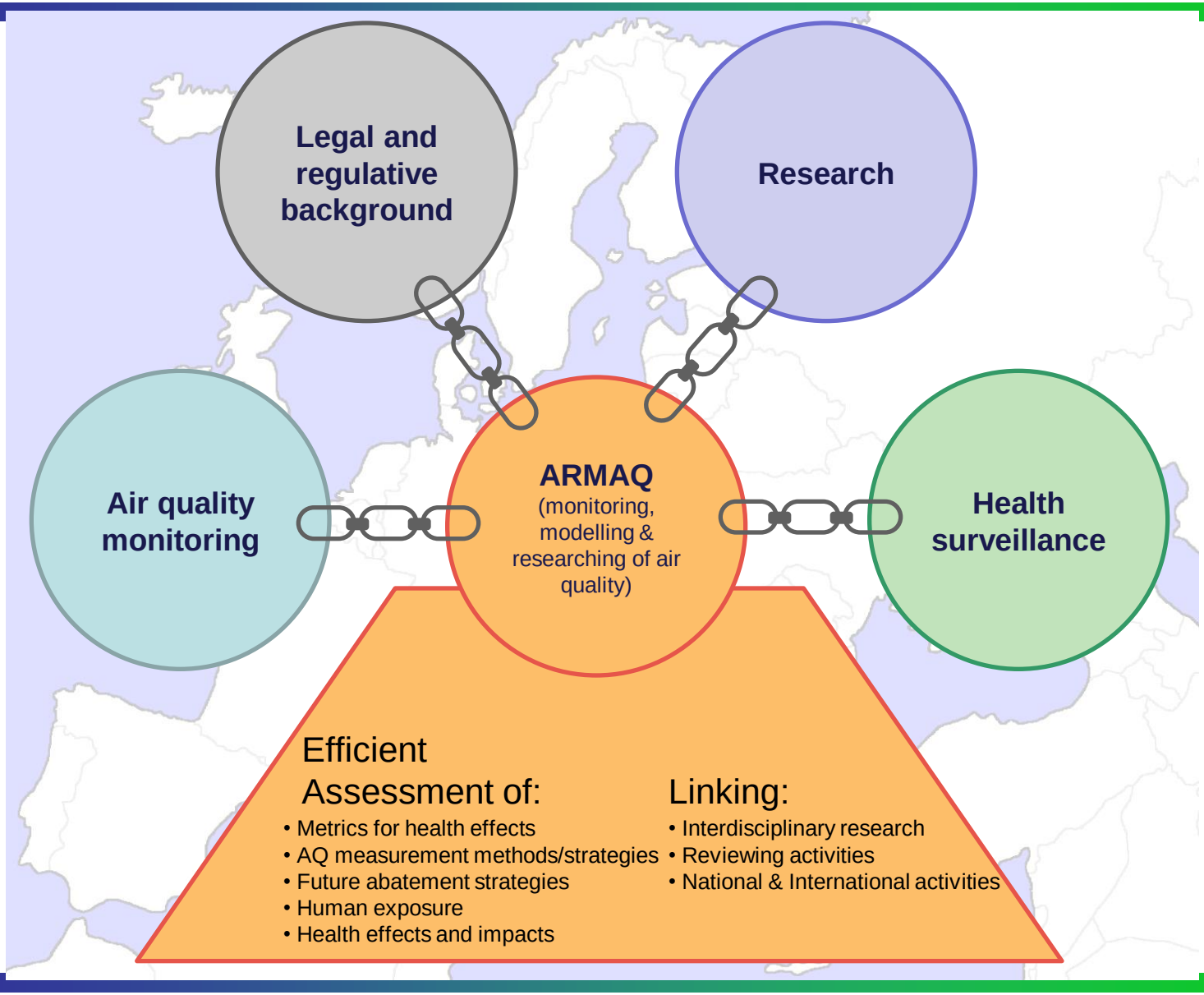
Europe



Agglomeration areas in Europe

all different approaches?

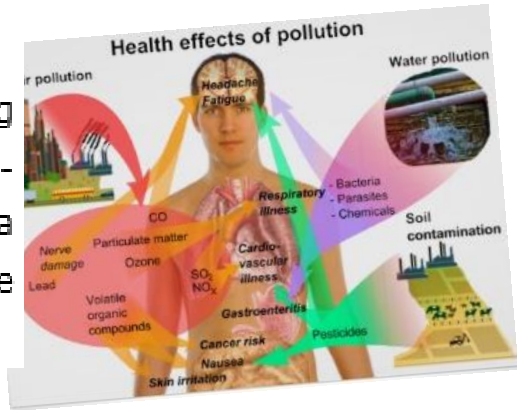
ARMAQ (Areas for Researching and Monitoring Air Quality)



Air Quality Monitoring

The future challenges for urban air quality monitoring in Europe are to fill the gaps in information related to spatial and temporal variations of exposure to health-relevant air pollutant metrics. Routine monitoring should address multiple purposes e.g. compliance assessment, effectiveness of AQ action plans, routine health monitoring and assessment, and impact assessment. Therefore following R&D steps are needed:

Areas for Research and Monitoring of Air Quality (ARMAQ,) focussed on human health have to be developed in various densely populated areas in Europe, to enable the development and integration of new measurement technologies, measurement strategies, data integration and analysis tools, as well as testing new exposure metrics (e.g. EC) and exposure assessments.



These ARMAQs should be closely linked to health effect studies by including routine health data recording, health effect studies, and health impact assessments, including using different types of cohorts. This may be extended in a second step to the inclusion of other environmental stressors to allow more complete health effect studies.

Thanks

- to you
- to my colleagues
- to the AirMonTech-project partners

AirMonTech Consortium: (from left) J. Moeltgen (UDE), U. Quass (IUTA), K. Torseth (NILU), K. Katsouyanni (NKUA), B. Vogel (UDE), R. Otjes (ECN), E. Weijers (ECN), P. Woods (NPL), T. Kuhlbusch (IUTA, Coordinator), P. Quincey (NPL), M. Viana (CSIC), R. Gehrig (EMPA), X. Querol(CSIC,) A. Borowiak (JRC), C. Hueglin (EMPA).