Karlsruhe Institute of Technology

UrbENO - an urban observatory in the context of larger holistic research strategies

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Some urban facts

- Since **2007** more than **50 %** of the world's population live in urban agglomerations; it is estimated that **70 %** do so by **2050**
- Until 2030 there will be **59 cities** with more than 5 000 000 inhabitants and **23 megacities** with more than 10 000 000 people. (Brennan-Galvin 2000)
- Urban agglomerations in China increased from **20 % to 41 %** (between 1980-2005)
- Europe has an **urbanization rate of 72 %**
- **1.2 %** of the land surface is considered to be urban

Interaction of urban agglomerations with Global Change

cities ➔ trace gas emission ➔ changed radiative properties of the air
➔ contribution to global warming

➔ aerosol production ➔ changed clouds and precipitation patterns
➔ regional dimming

➔ heat ➔ changed regional circulations

➔ growing urban population ➔ more emissions
➔ more heat
➔ more fresh water demand

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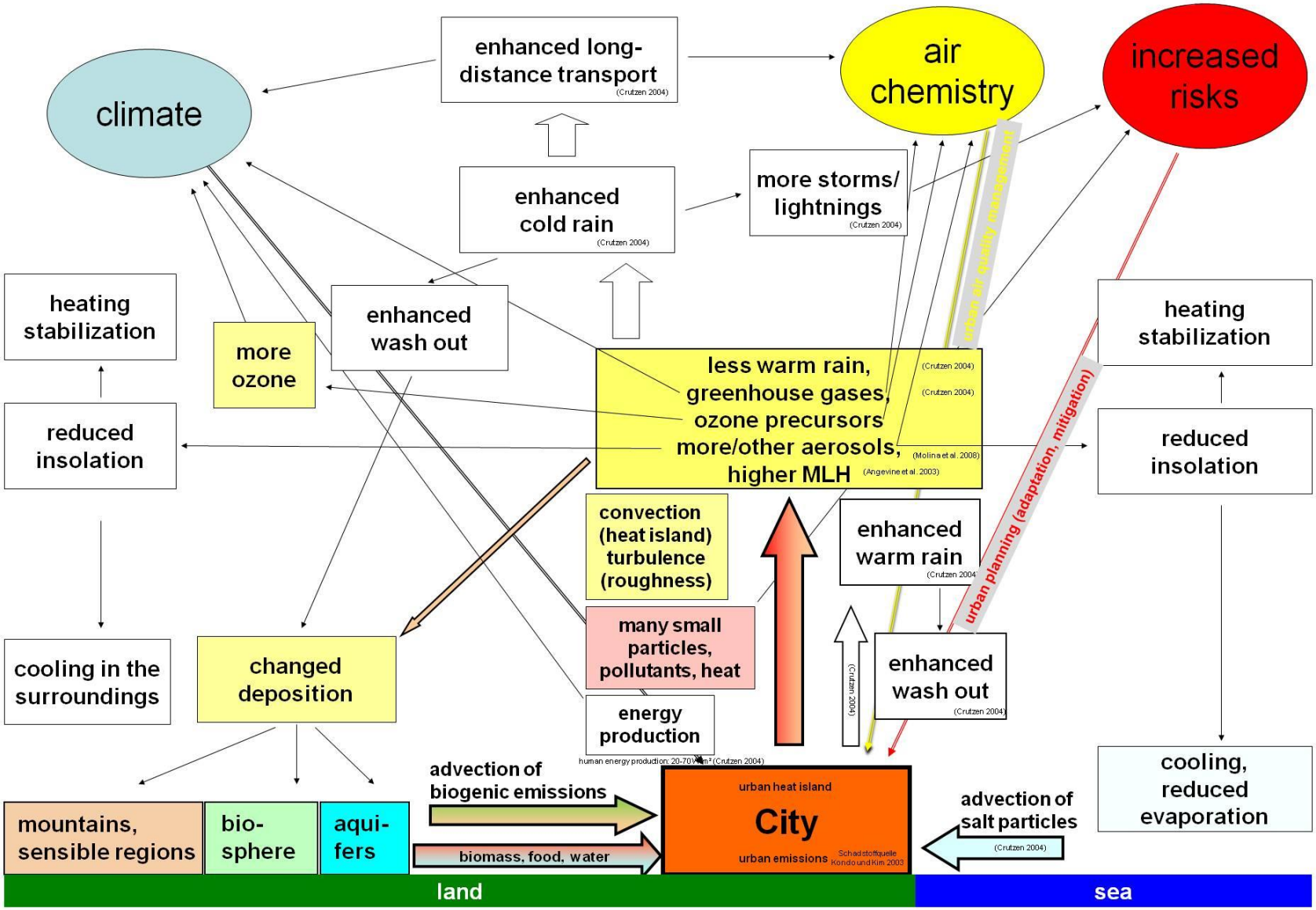
Global Change ➔ warmer and partly dryer climate ➔ even warmer cities
➔ less fresh water availability

➔ more people ➔ larger cities ➔ larger climate impacts
➔ problems in food and water supply

Colour code: radiation; air dynamics; air quality/chemistry; **water cycle**

A city and its regional interrelations due to climate change, anthropogenic emissions and energy production



Institute for Meteorology and Climate Research – Atmospheric Environmental Research

Peculiarities of the climate in **urban agglomerations**

buildings ➔ flow obstacles ➔ reduced mean wind speed
➔ increased turbulence
➔ flow convergence at upwind edge ➔ mean upward motion
➔ more clouds, precipitation
➔ trapped short wave radiation (multiple scattering in street canyons, etc.)
➔ retained long wave radiation (reduced sky view)
➔ storage of heat

impervious surfaces ➔ stronger run off during precipitation events
➔ less humidity available for evaporation

less vegetation ➔ less humidity available for evaporation

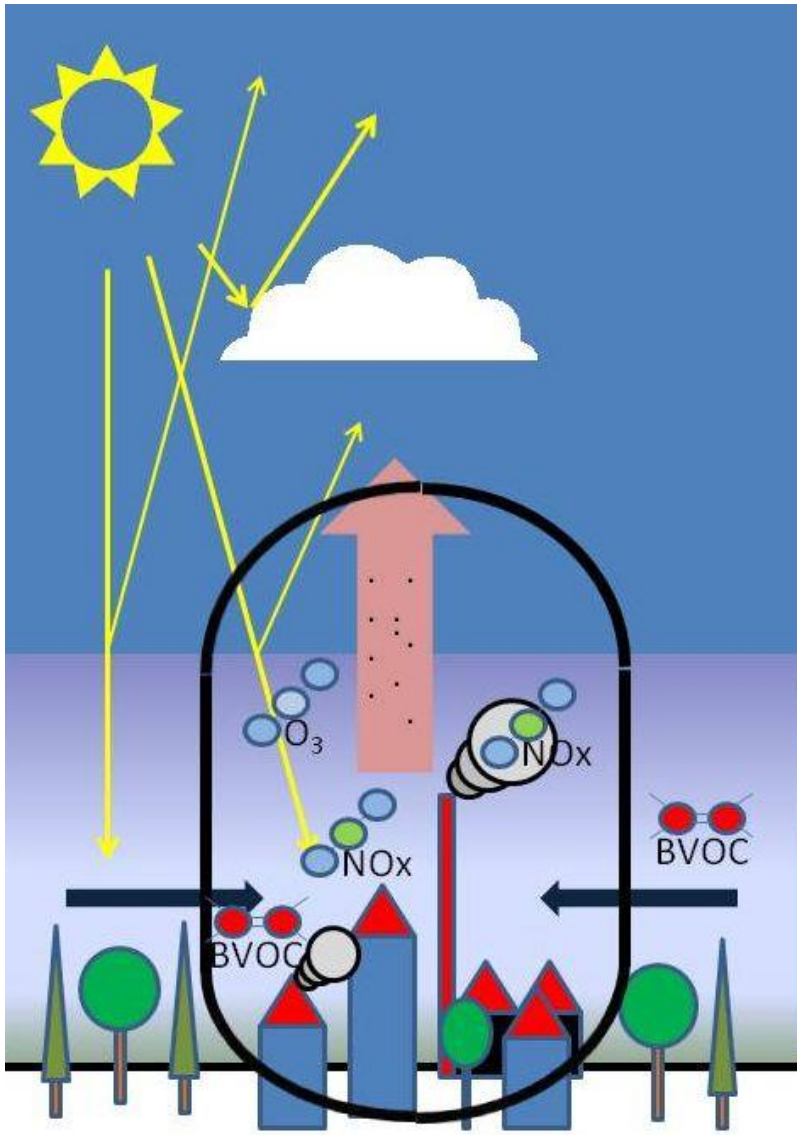
human beings ➔ anthropogenic heat production
➔ trace gas emissions ➔ changed chemical properties of the air
➔ reduced air quality ➔ health risks
➔ aerosol production ➔ changed clouds, precipitation
➔ reduced air quality ➔ health risks
➔ reduced visibility

.....

excess heat ➔ upward motion over cities ➔ compensating inflow from rural areas
(UHI) ➔ enhanced chemical reactions ➔ photo-oxidants ➔ health risks
➔ health risks (missing cooling at night)

Colour code: radiation; air dynamics; air quality/chemistry; **water cycle**

The urban ecosystem – a reaction chamber with global impact



Internal processes and exchange with surrounding compartments of the Earth system

- urban heat island

- secondary circulation

- natural emissions (inside and outside of the cities)

- anthropogenic emissions

- air chemistry, aerosol formation

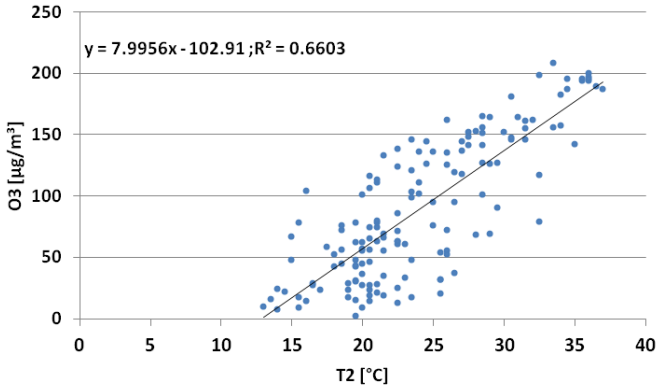
- impact on local and regional air quality

- impact on regional and global climate

Interaction of urban agglomerations with air quality

cities ➔ trace gas emission ➔ changed atmospheric composition
➔ changed atmospheric cleansing potential
➔ reduced air quality
➔ production of secondary trace gases (e.g., ozone)

➔ aerosol production ➔ reduced air quality
➔ reduced photolysis
➔ increased deposition



Correlation between measured ozone and temperature at an urban centre

➔ less winds ➔ reduced air quality

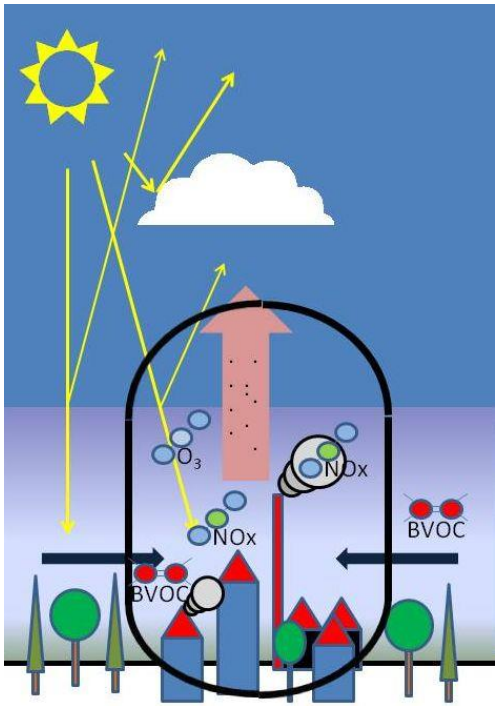
➔ more heat ➔ faster chemical reactions (e.g., more ozone)
➔ shifted chemical equilibria
➔ secondary circulations bring rural biogenic and urban anthropogenic emissions together
➔ enhanced import of fresh air

Colour code: radiation; air dynamics; air quality/chemistry; **water cycle**

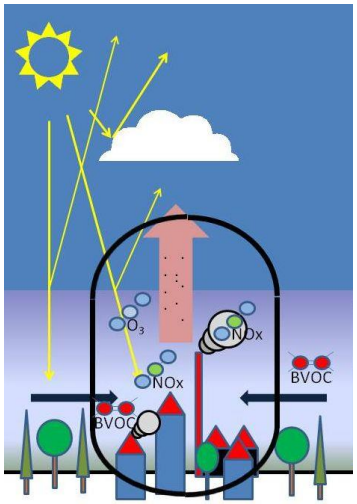
Photo: 2011 Stefan Emeis

Warmer cities influence local and regional climate (Clouds over Manhattan on May 28, 2011)

UrbENO - an urban observatory



UrbENO



Why UrbENO

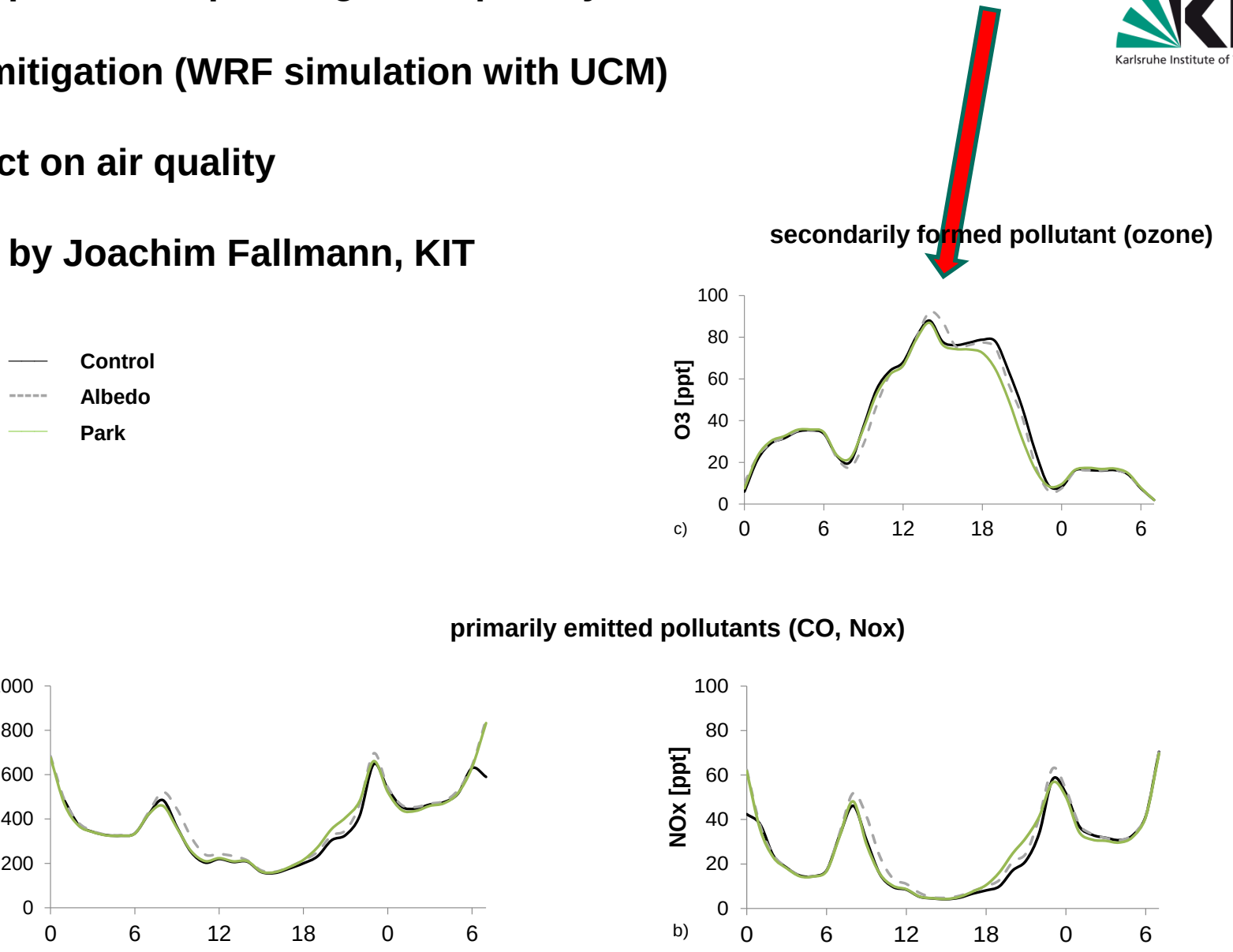
- understand how a complex system is working
- understand the possible impacts of global/climate change on cities
- being able to manipulate such a complex system towards sustainability

Example of manipulating a complex system

UHI mitigation (WRF simulation with UCM)

impact on air quality

done by Joachim Fallmann, KIT



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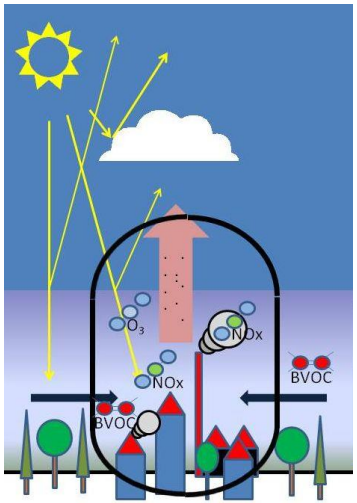


Basic questions

- what data is needed for future urban research, planning, development and policies?
- how can this data be provided?
- how can future monitoring strategies look like which capture complex temporal and spatial dynamics?
- which challenges emerge from the enormous amount of data?
- how can this data (and subsequent research results) be stored and made available to researchers and stakeholders?
- how to include citizens (their needs and abilities, social networks)?
- do unknown data sources exist which have not been accounted for so far?

involving citizens / recently unknown data sources

Cell phone fine dust sensors

Clean air alongside busy roads?
The smartphone fine dust sensor is intended to measure concentration in real time.
(Photo: Patrick Langer, KIT)

Institute of Telematics
Chair for Pervasive Computing Systems / TECO

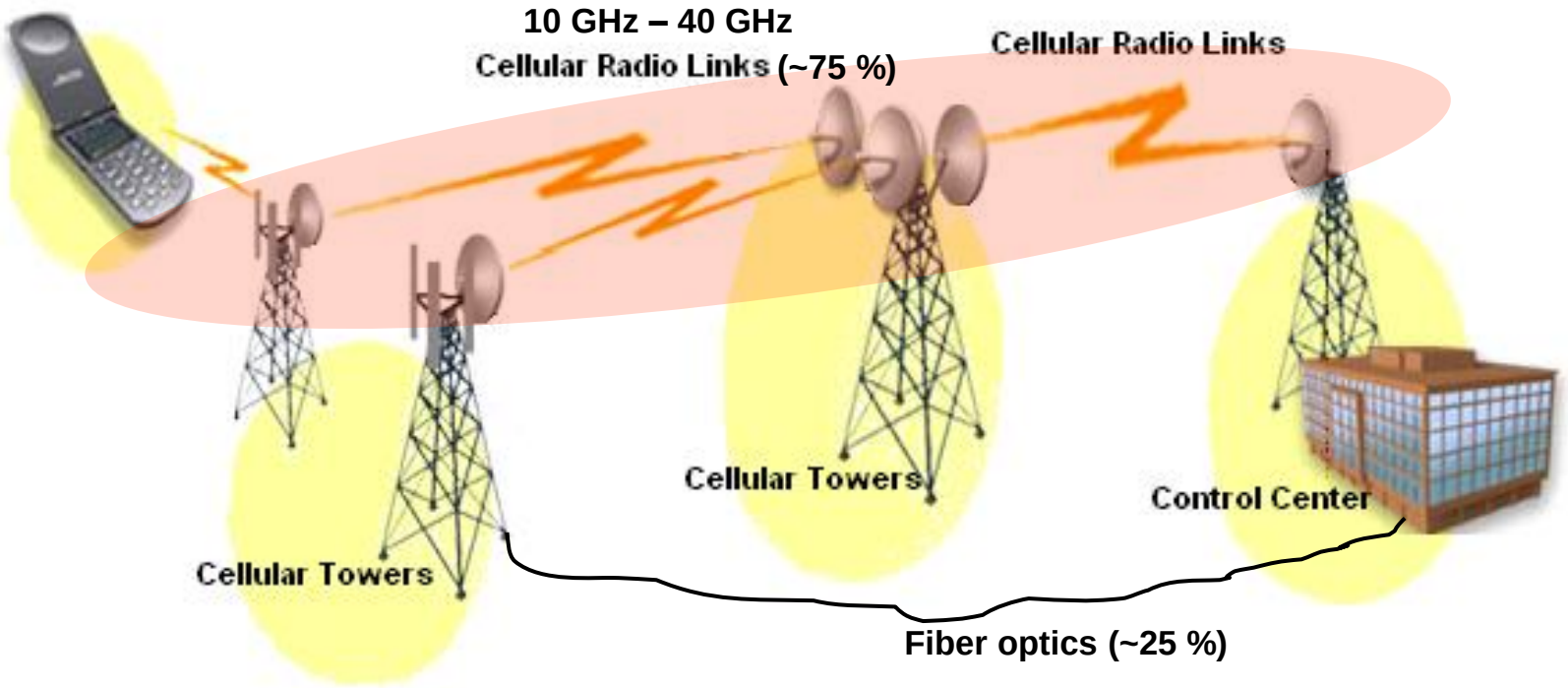
Project: FeinPhone

START/END
•03/2015 – 06/2016

PARTNERS
•Siemens AG

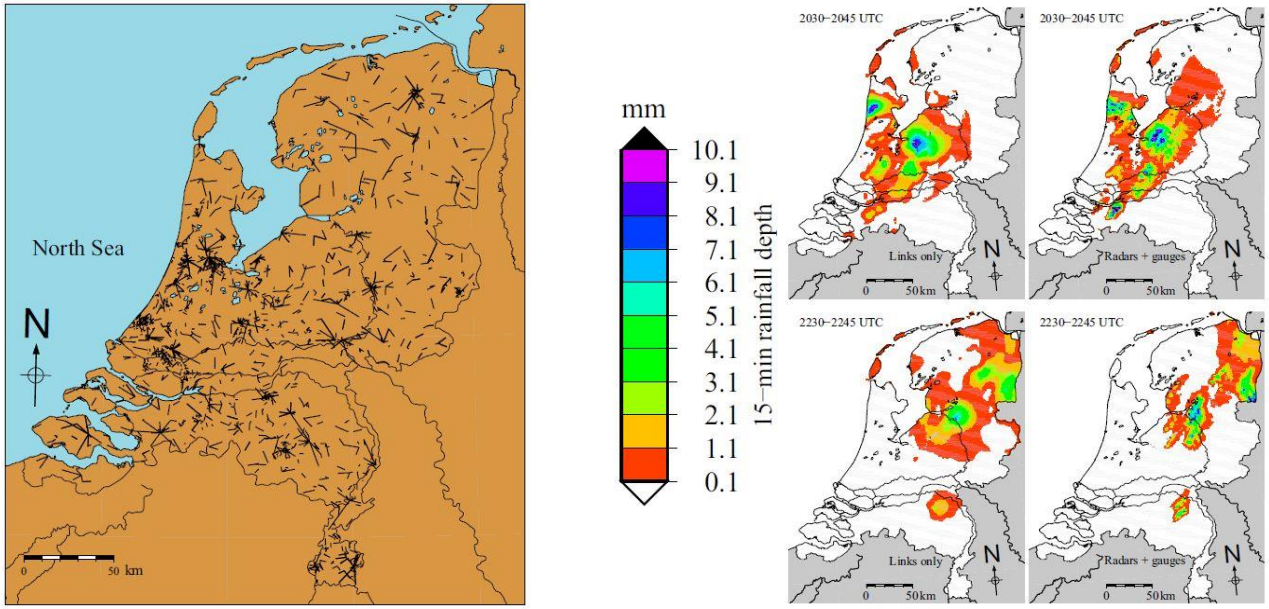
RESEARCH TOPICS
•Environmental Sensing
•Mobile Computing
•Participatory Sensing

Cell phone signal attenuation by atmospheric humidity and precipitation



involving citizens / recently unknown data sources

precipitation maps from microwave attenuation



Cell phone network **radar network**

Source: Overeem, A., Hidde Leijnse, Remko Uijlenhoet, 2013: Country-wide rainfall maps from cellular communication networks. PNAS, **110**, 2741-2745.

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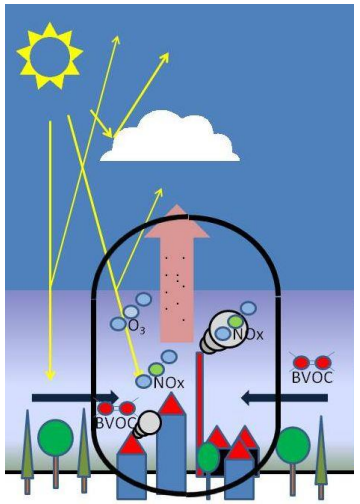
Challenges



related to the urban system

- high dynamics and complexity of urban development (partly unplanned)
- complex large-scale spatial and socio-economic dimensions and connections
- small-scale multitude of different compartments (representativeness?)
- highly varying entities of spatial and socio-economic relations
- high density and partly overlapping of different land use

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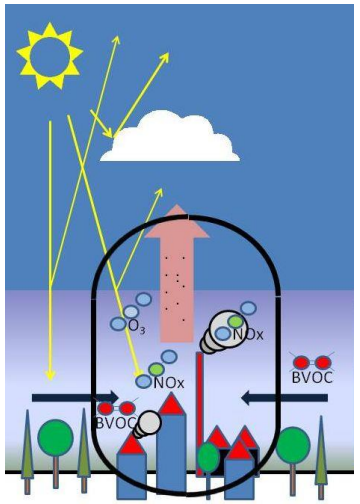
Challenges

related to the monitoring systems



- integration of a large multitude of data capture and monitoring systems
- necessity of defining and shaping reference systems
- large amounts of highly heterogeneous data (e.g., different time base)
- short update cycles due to dynamic developments
- provisions for multi-scale assessments, up- and downscaling options

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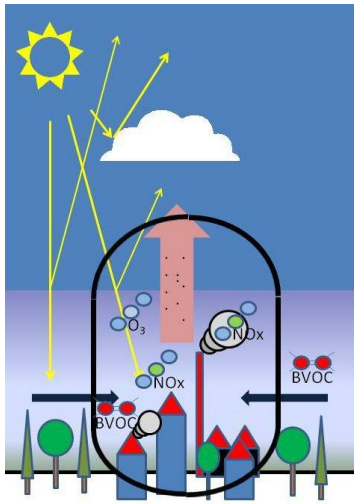
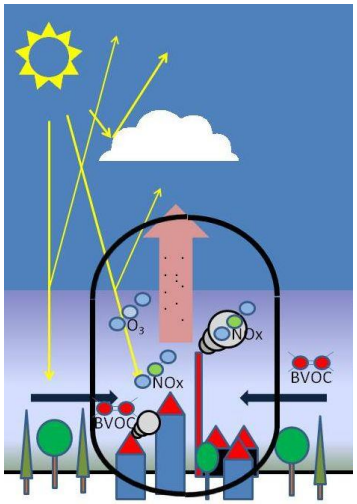
Challenges



related to data storage and dissemination

- integration of a large multitude of heterogeneous data
- harmonisation of heterogeneous data
- data quality assessment and control (QA/QC)
- provision of meta data
- storage media
- extraction software for various users

Existing/earlier projects



Germany:

HGF: TERENO, Risk Habitat Megacities

DFG: Megacities – Megachallenge
BMBF: Future Megacities

Europe:

IUME (EEA, Towards an Integrated Urban Monitoring in Europe)
ClearfLo (Clean Air for London)
Lyon (existing urban data base)
Santander (existing urban data base)

USA:

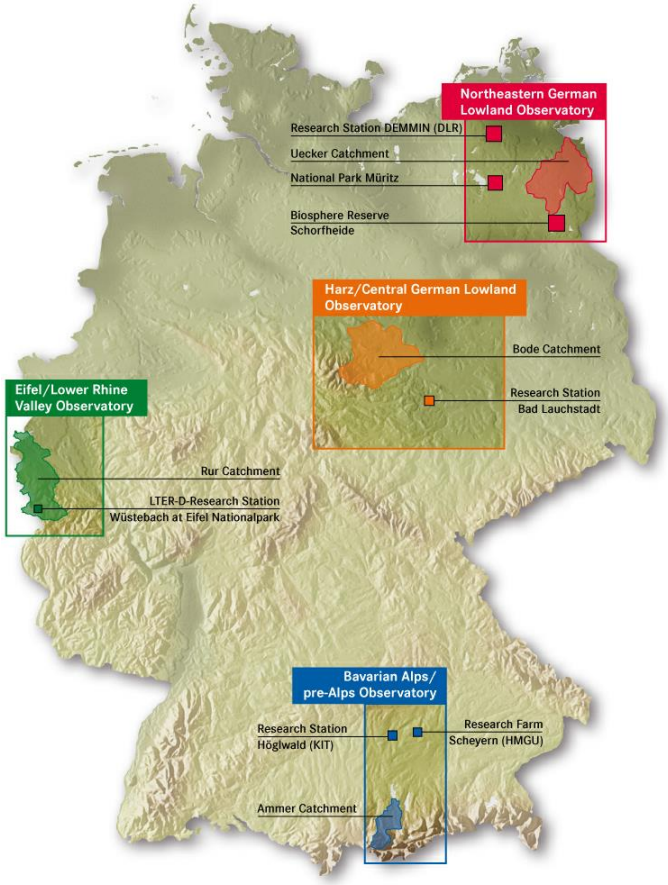
NEON (National Ecological Observation Network), LTER (Long-term Ecological Research Network)

Intern'l:

AURIN (Australia Urban Research Infrastructure Network)

TERENO
TERRESTRIAL ENVIRONMENTAL OBSERVATORIES

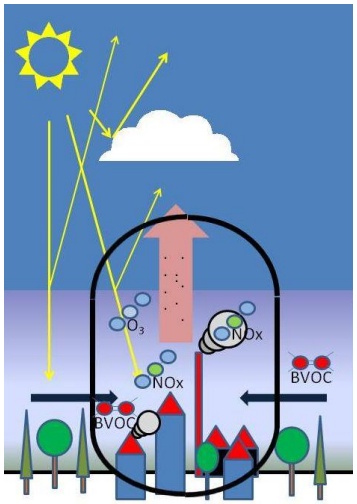
The TERENO Network



- "aims to determine the long-term ecological and climatic impact of global change at regional level"
  - the effects of Global Change on terrestrial systems are regionally differentiated
    → requires a network approach
  - … with complex feedbacks between compartments (soil, water, bio-, atmosphere)
    → requires a platform approach
  - long-term observation
    - as non-manipulative field experiment
    - detection of trends
    - validation of terrestrial environmental models

UrbENO will be in some analogy to TERENO and complements it.

UrbENO

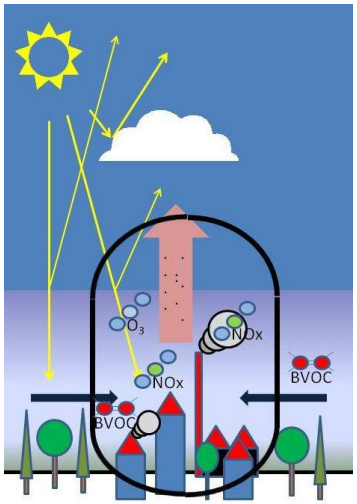


embedded into larger programs / initiatives

- KIT urban research (survey of existing competence)
- Helmholtz Association (HGF) urban research initiative
- Germany: national platform “City of the Future” (NPZ, Nationale Plattform Zukunftsstadt)
- Europe: Horizon2020: “smart cities”

all these programs / initiatives are heading for a more holistic approach, not just ecosystem exchange fluxes

UrbENO



coordinated within the Helmholtz Association (HGF)
open to other groups

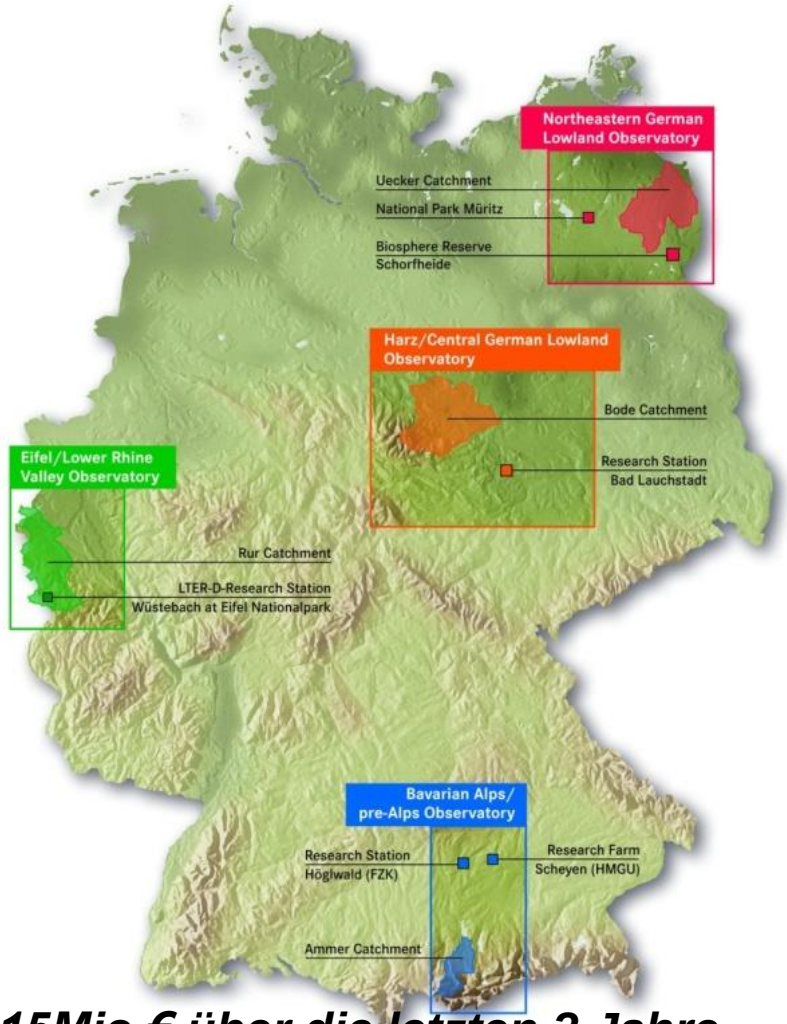
tentative schedule

2016-2017	conceptual work
2018-2019	first observational sites
2020-20….	operational phase


Vielen Dank für
Ihre
Aufmerksamkeit

Die TERENO-Observatorien

TERENO
TERRESTRIAL ENVIRONMENTAL OBSERVATORIES



Σ = 15Mio € über die letzten 3 Jahre

JÜLICH FORSCHUNGSZENTRUM

HELMHOLTZ ZENTRUM FÜR UMWELTFORSCHUNG UFZ

HelmholtzZentrum münchen
Deutsches Forschungszentrum für Gesundheit und Umwelt

DLR

GFZ
Helmholtz-Zentrum POTSDAM

KIT
Karlsruhe Institute of Technology

TERENO: Ziele & Fragen

TERENO
TERRESTRIAL ENVIRONMENTAL OBSERVATORIES

Ziel

Eine **interdisziplinäre** und **langfristige** Beobachtungsplattform schaffen
(in enger Zusammenarbeit mit *Helmholtz-Gemeinschaft* & Universitäten)

Forschungsfragen

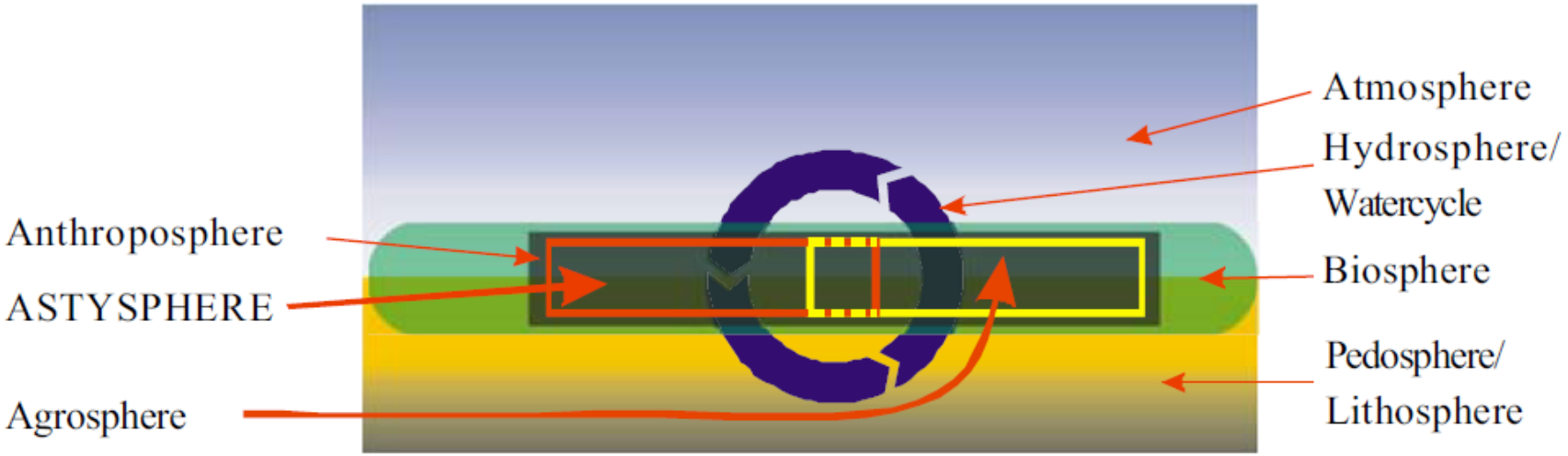
- **Konsequenzen der** beobachteten und erwarteten **Klimaänderung** auf Grundwasser, Böden, Vegetation, Fließgewässer)
- **Rückkopplungen** zwischen **Landoberfläche & Atmosphäre** (Wasser, Stoffe, Energie)
- Einflüsse von **Böden und Landnutzungsänderungen** auf Wasserhaushalt, Bodenfruchtbarkeit, Biodiversität und regionales Klima
- Konsequenzen **anthropogener Eingriffe** auf terrestrische Systeme

Anthroposphere comprises cities and agricultural areas

Urbanisation has been the most drastic change in land use and land surface properties ever.

Stefan Norra therefore suggested the term **astysphere**.

The **astysphere** surrounds the globe like a spider net. The knots are the cities, and the silks represent the connecting transport network (Norra 2009).



from: Norra 2009