Air pollution, Climate Change and Health
A challenge for multidisciplinary research

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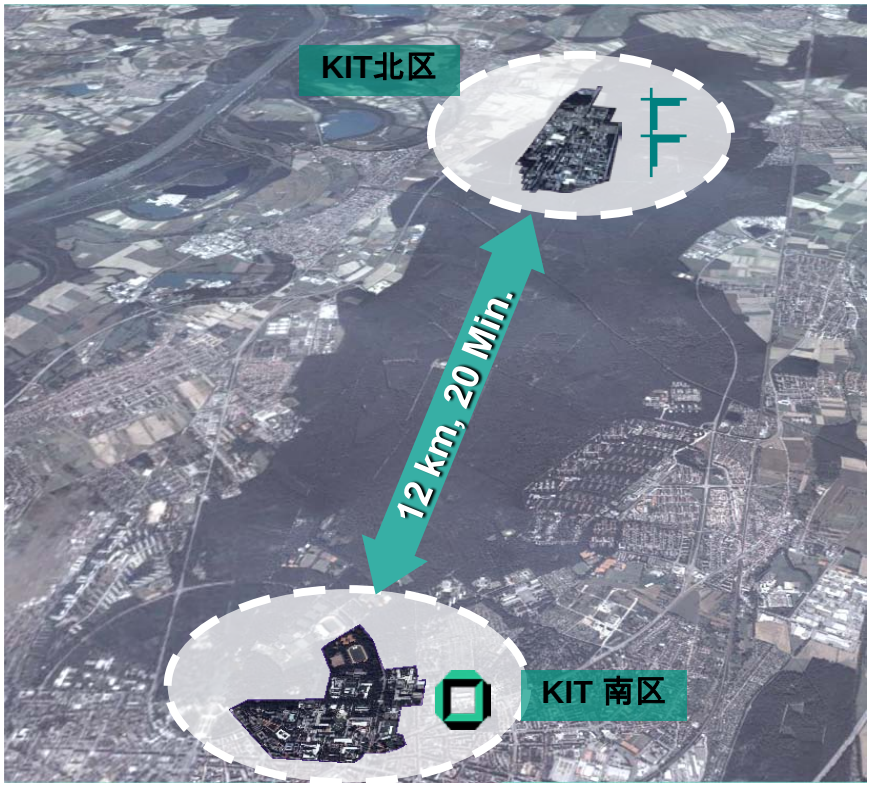
Campus Alpine, Germany

Overview

- *Where I come from*
- Facts and Problems
- Methodological Approach
- Results
- Conclusions

卡尔斯鲁厄科技研究所



KIT

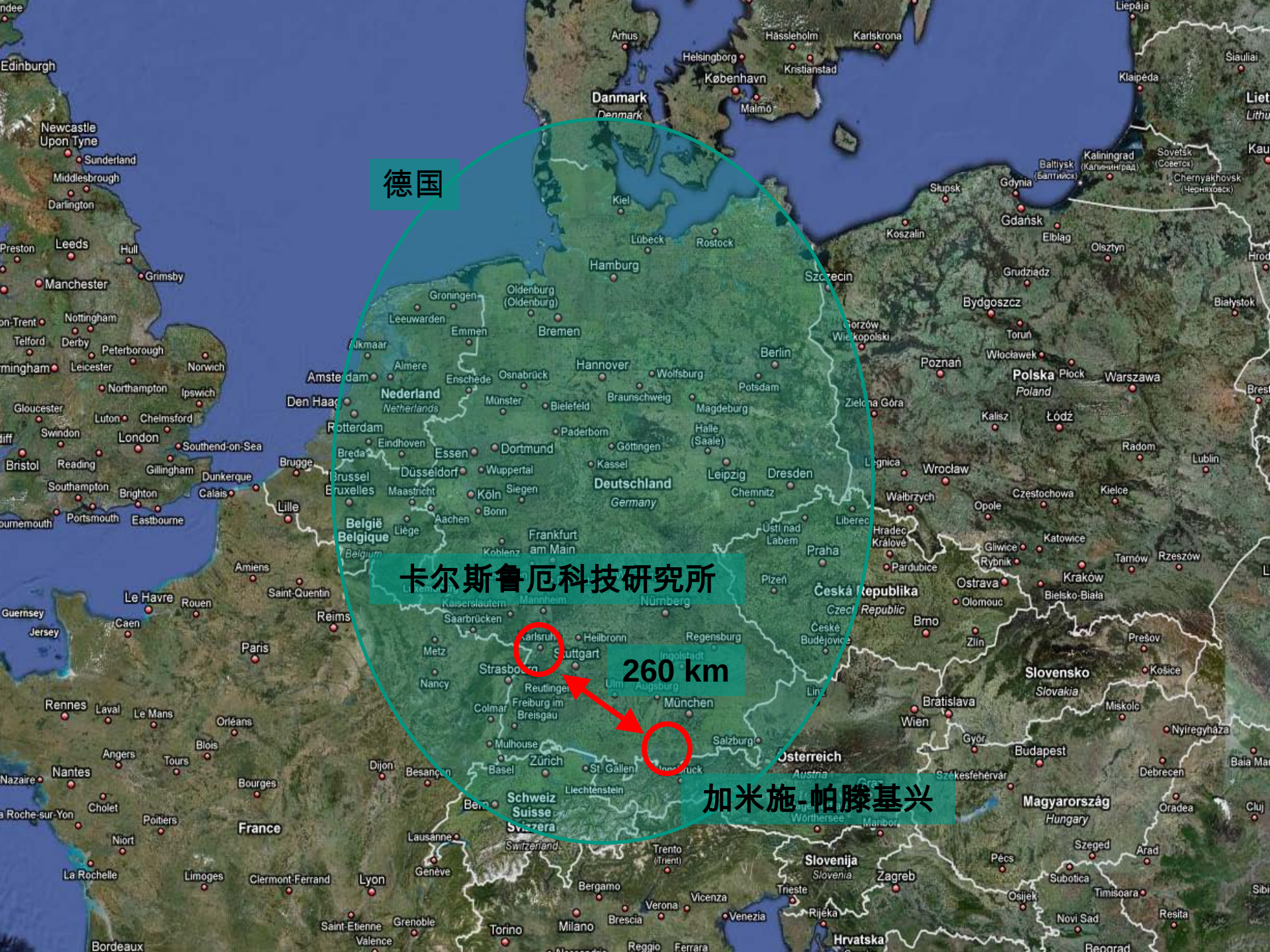
卡尔斯鲁厄研究中心		卡尔斯鲁厄大学
10	计划	11
31	研究所	118
3690	研究人员	4269
408 Mio €	经费	18353
		299 Mio €

	成员	
	研究所	
	研究人员	
	学生	
	经费	

自然和工程科学

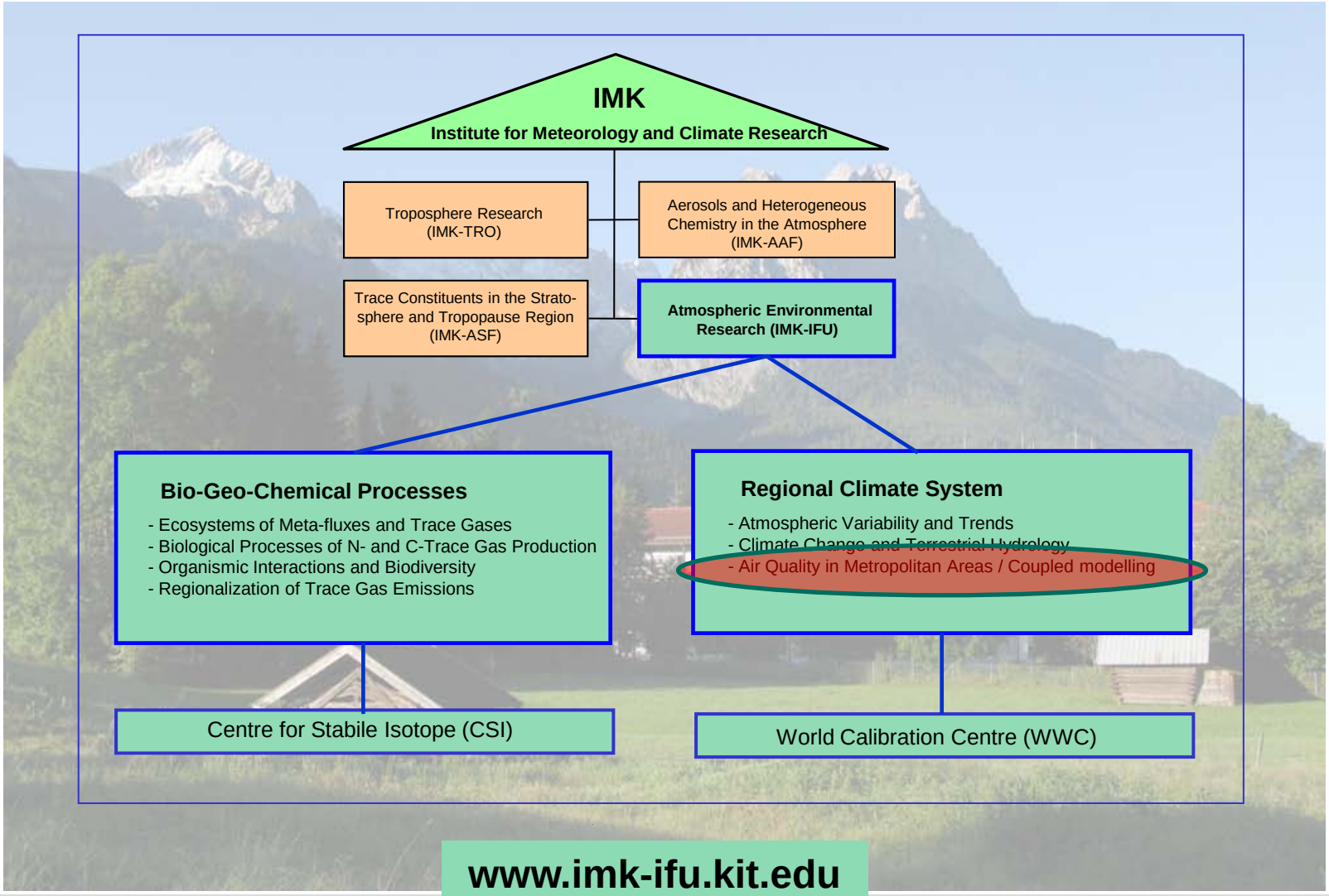
260 km

– KIT 阿尔卑斯区–


德国
卡尔斯鲁厄科技研究所
260 km
加米施-帕滕基兴


卡尔斯鲁厄气象与气候研究所
– KIT 阿尔卑斯区–
德国最高峰
楚格峰 2962米
gemeindefreies Gebiet
Deutschland
Österreich
Enningalm
Farchant
Burgrain
Friederalm
Rotmoosalm
Schweizer Alple
Garmisch-Partenkirchen
Gerold
Kaltenbrunn
Kainzenbad
Wamberg
Elmauer Alm
Klais
Griesen
Untergrainau
Grainau
Obergrainau
Hammersbach
Vordergraseck
Hintergraseck
Elmau
Bayern
Tirol
Bockhütte
Lermoos
Ehrwald
Biberwier
Ahrn
Gasse
Leutasch
Weidach
E533
187
179
2

Institute for Meteorology and Climate Research (IMK-IFU)



www.imk-ifu.kit.edu

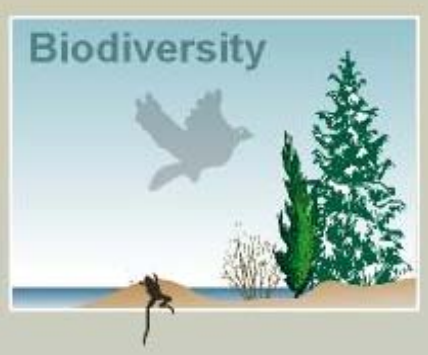
Atmospheric Environmental Research

大气环境研究

平流层臭氧损耗

空气质量

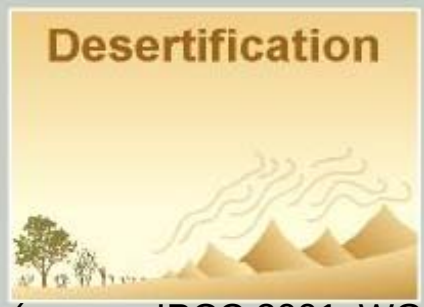
生物多样性



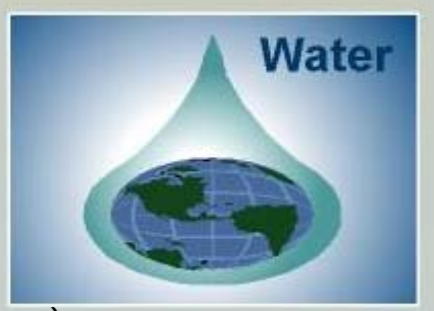
Climate Change

气候变化

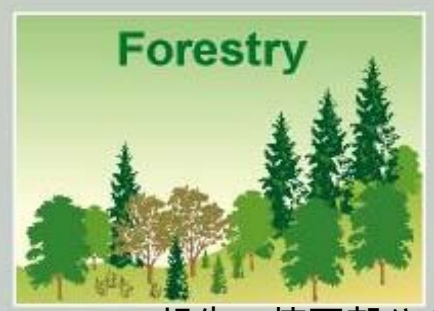
沙漠化



水



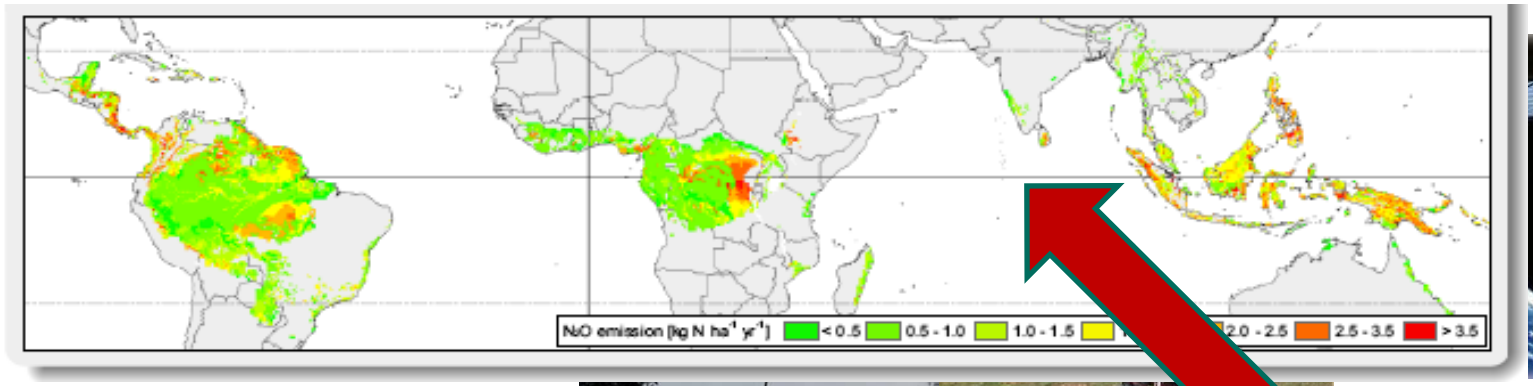
森林

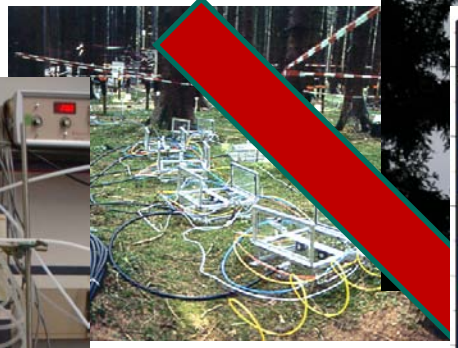


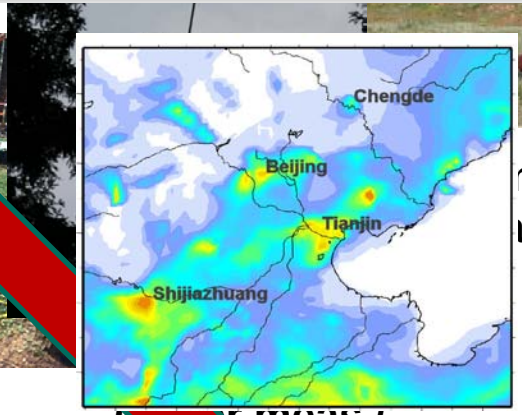
(source: IPCC 2001, WG1 Report, Summary)

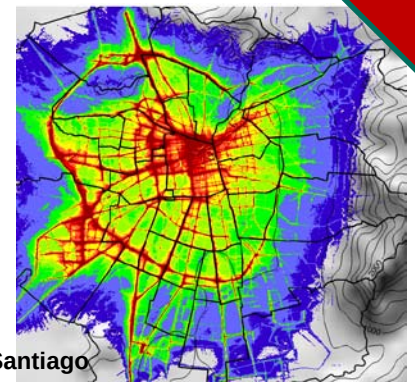
（来源：IPCC2001, WG1报告，摘要部分）

The Challenge









global scale
mote sensing)

nal scale
ft meas.)

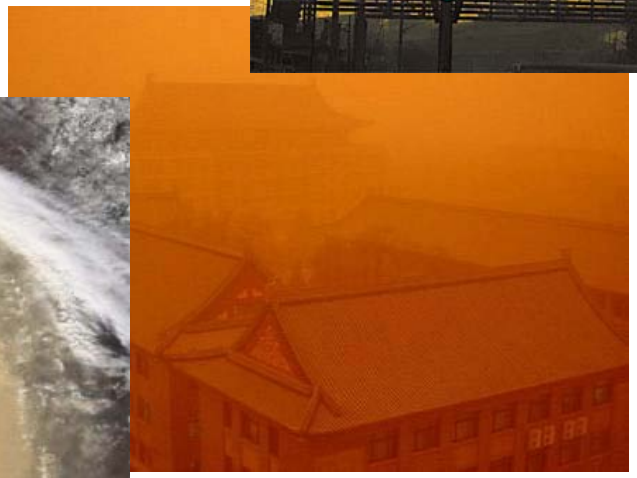
plot scale
(chamber meas.)

meas./
nsing)

(laboratory meas.)

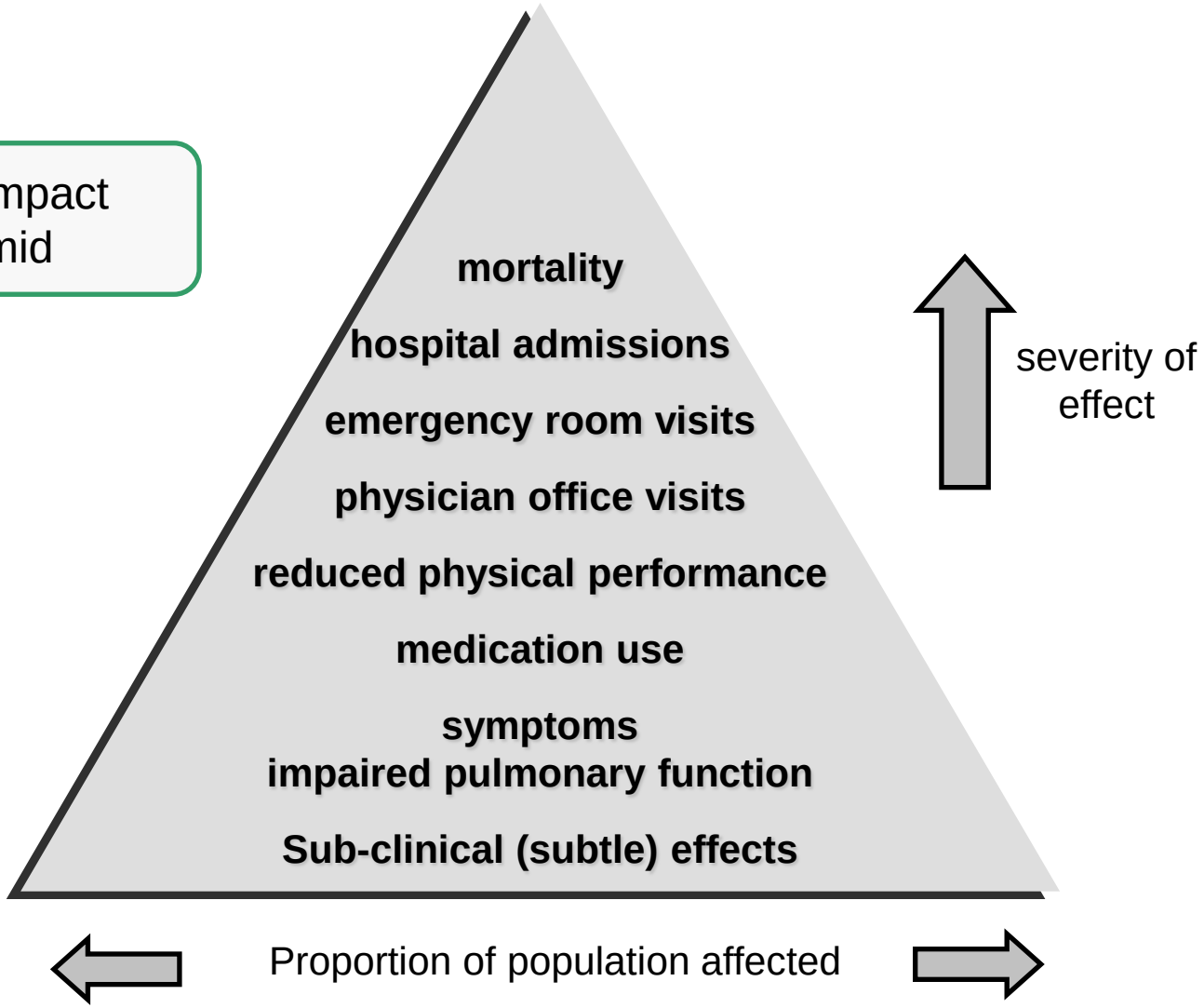
…from measurements to modeling
…from the micro to the macro scale and vice versa

Facts and Problems

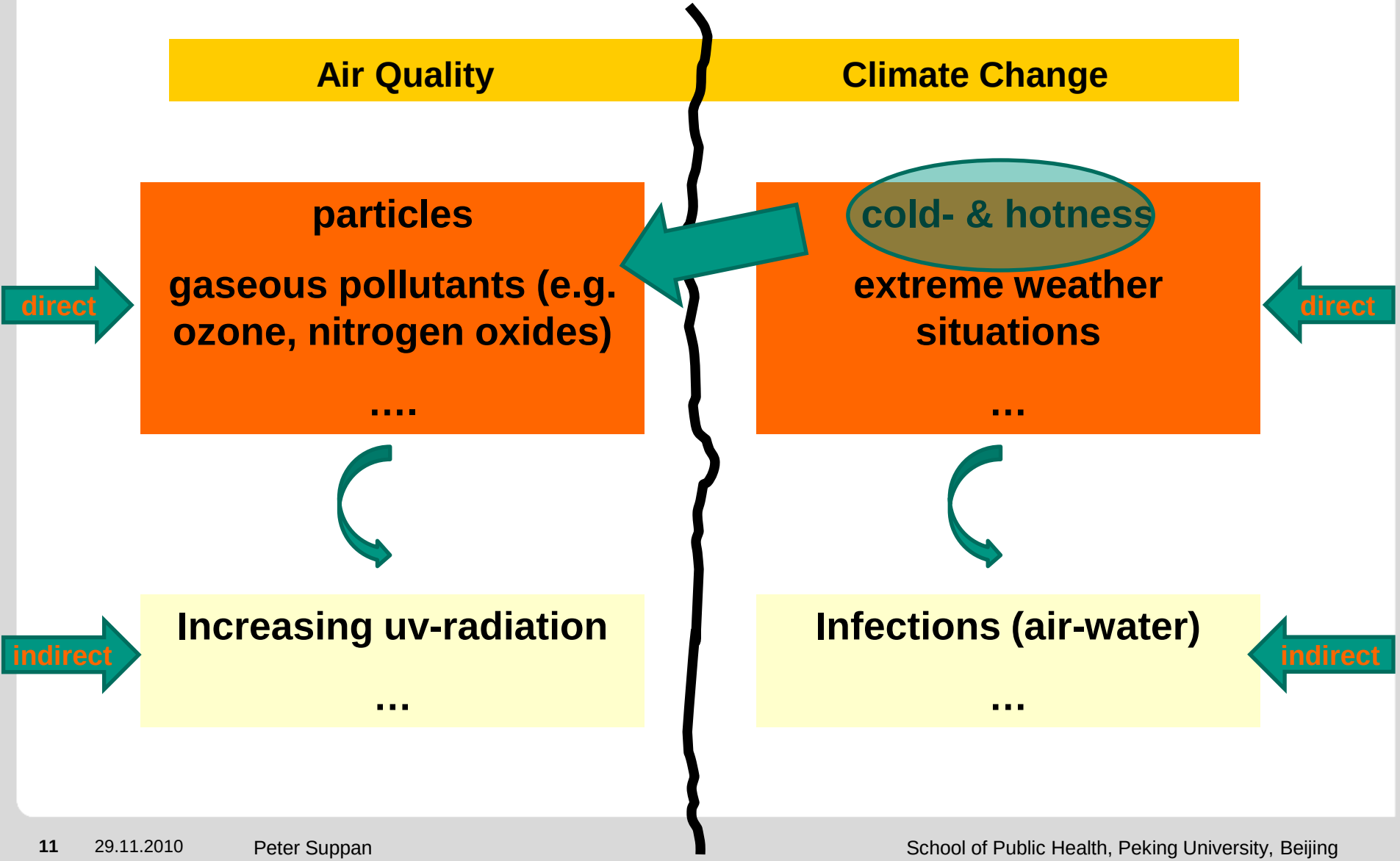


Driving Force: Health Impact

Health Impact Pyramid

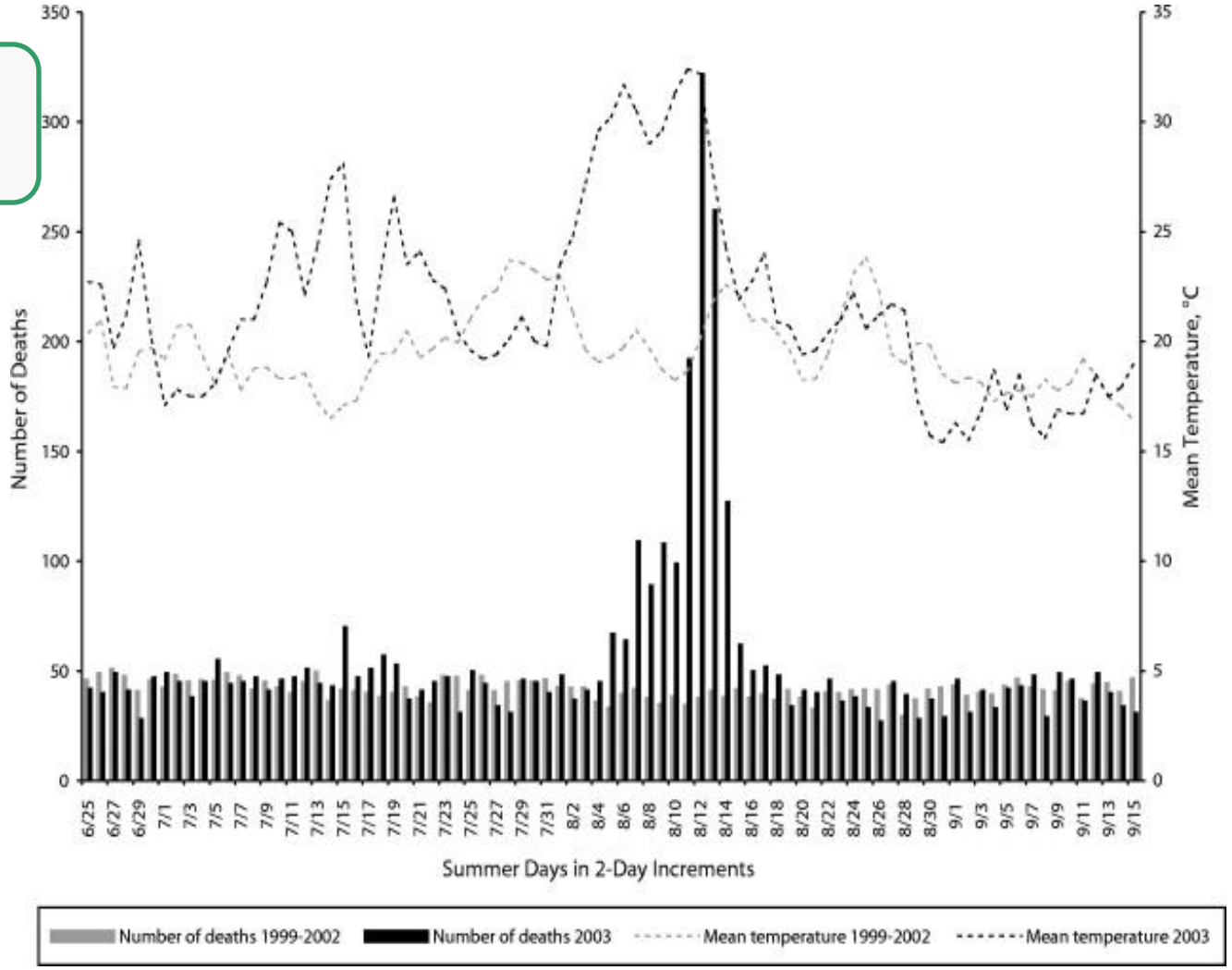


Causes


Air Quality
Climate Change
particles
gaseous pollutants (e.g. ozone, nitrogen oxides)
....
cold- & hotness
extreme weather situations
...
direct
direct
Increasing uv-radiation
...
Infections (air-water)
...
indirect
indirect

Meteorology / Climate: Impact

Heat waves and mortality

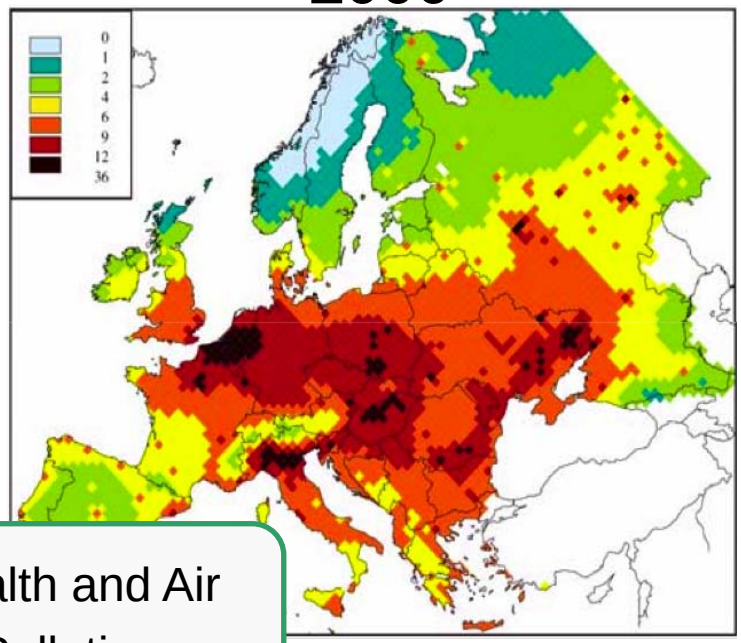


Source: Vandentorren et al. 2004

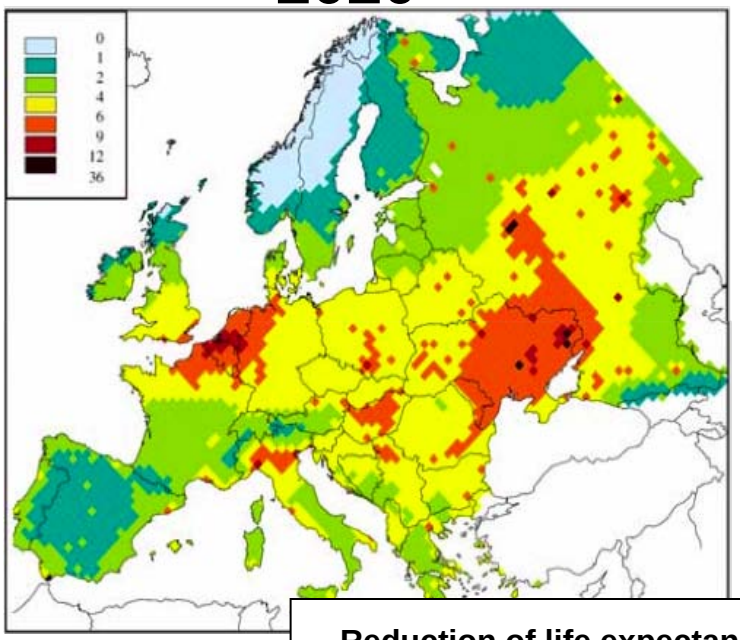
Air Quality Impact

Karlsruhe Institute of Technology

2000



2020



Health and Air Pollution

Reduction of life expectancy in month due to of $PM_{2.5}$

EU-average 2000 vs 2020:

- Life expectancy reduction of 9 months – reduced to 6 months
- Annual loss of 4 Mio. life years – reduced to 2.3 Mio
- Annually 386.000 premature deaths – reduced to 251.000
- Annually 110.000 serious hospital admissions – reduced to 63.000

Source: CAFÉ (Clean Air for Europe), 2005

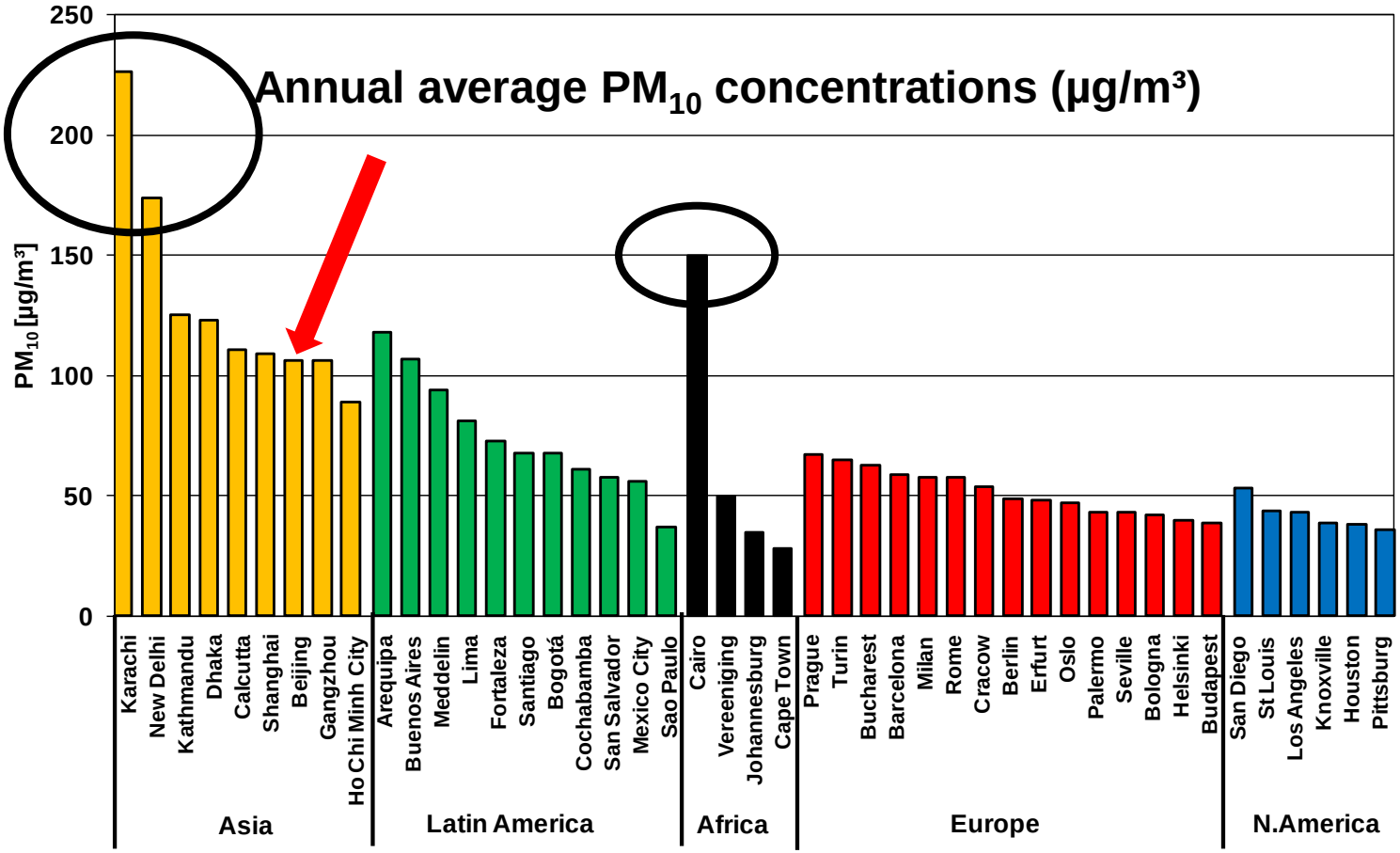
Mortality rates on PM_{10} increase

Region	Percentage change	Reference
Asia	4.9% (2.3%-7.6%)	HEI, 2004
Europe	6.0% (4.0%-8.0%)	Katsouyanni, 2001
Latin America	6.1% (1.6%-10.7%)	PAHO, 2005*
United States	2.1% (0.9%-3.3%)	Dominici, 2003
Worldwide	6.5% (5.1%-7.6%)	Stieb, 2002

PAN American Health Organization, 2005

* Based on studies in Mexico City, São Paulo, Santiago de Chile (per 10 µg/m³ PM_{10} change)

Economical Benefit

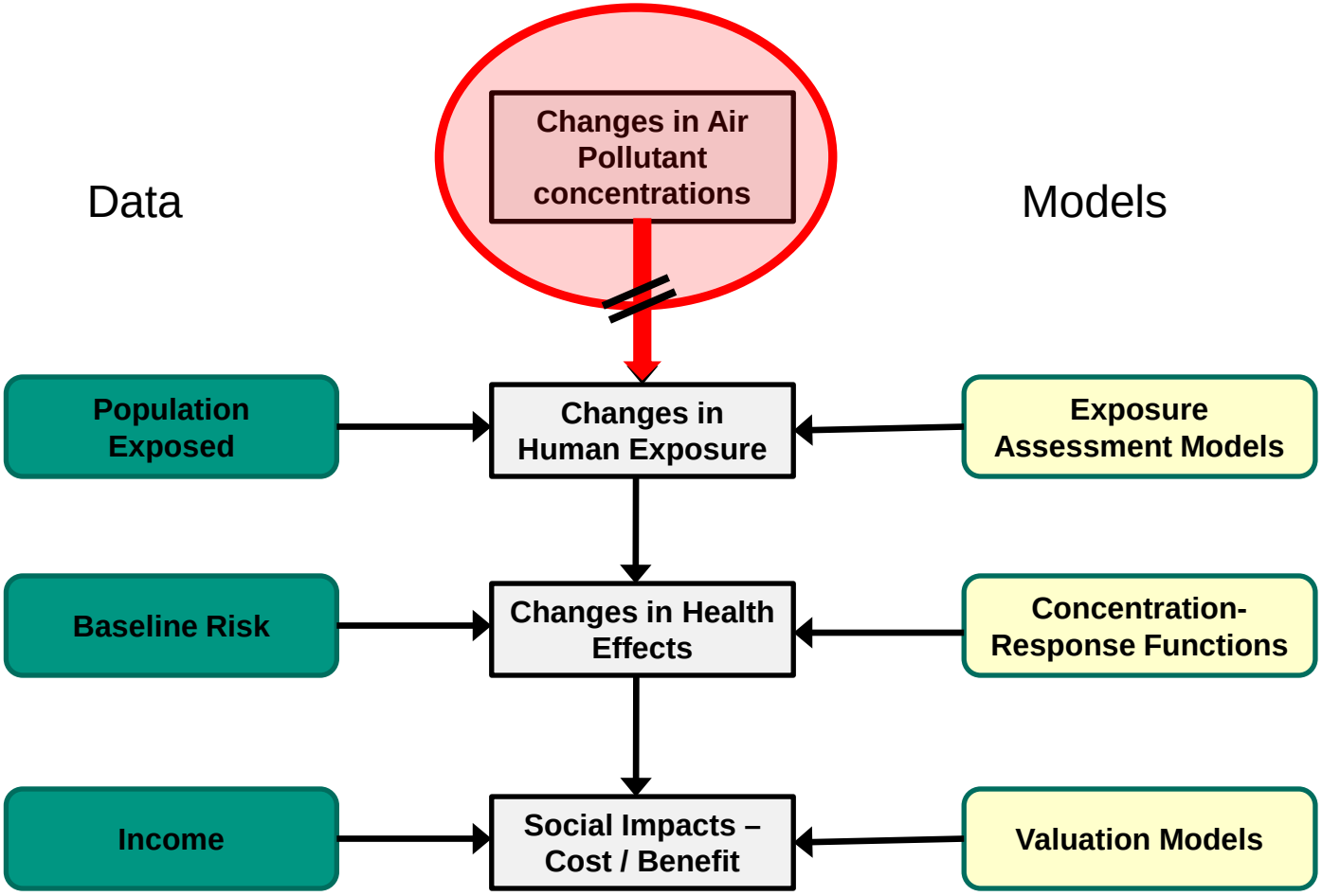


Reduction benefit is 10 times higher as for ozone, e.g. Mexico City about $2 Bill.

M. Krzyzanowski & H-G. Mucke, WHO
update by Jordan et al, CEPAL

Molina and Molina, 2002

Causal chain: Air Pollution-Health



Good policy flows from good data and from sound analysis

Cifuentes , etal 2005

State of the art

- **General correlations between air pollution and adverse health effects are well known**
- **Also the adverse health impact of single pollutants without cross correlations to others are well studied (but out of a mixture of pollutants it is hard to differentiate the impact of single pollutants)**
- **Correlation of Meteorology / Weather / Climate and human health is well known (espe. concerning the air temperature)**

Research needs…..

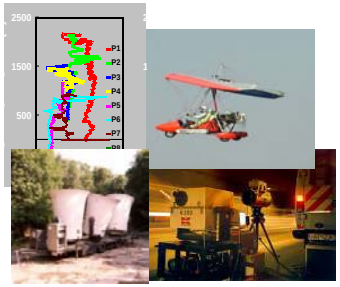
- **The complex chemical interactions of emission – transmission - air pollution - deposition / exposure need detailed investigations on the causal chain, e.g.**
  - **Source apportionment**
  - **Particle interaction / composition**
  - **Deposition rates / accumulation**
  - **(real) Exposure**
- **Circulation patterns → Regional-Urban interactions**
- **Climate Change Impact on these topics**
- **Only multidisciplinary approaches allow a holistic analysis**
- **….**

Methodological Approach

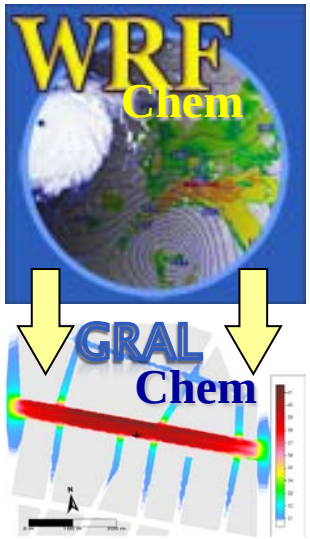
Karlsruhe Institute of Technology

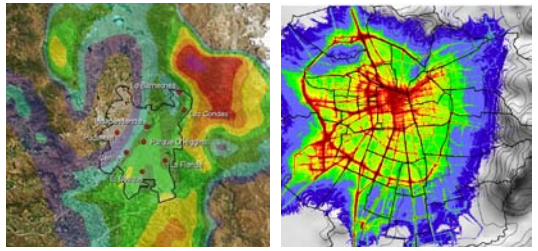
Urban Development

Measurement Data



Traffic Data

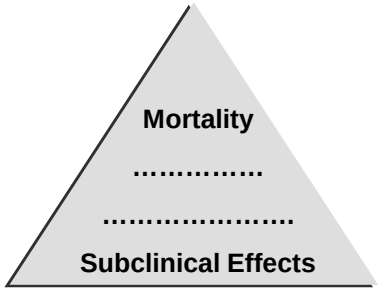




Air Quality

Scenario

Indicator

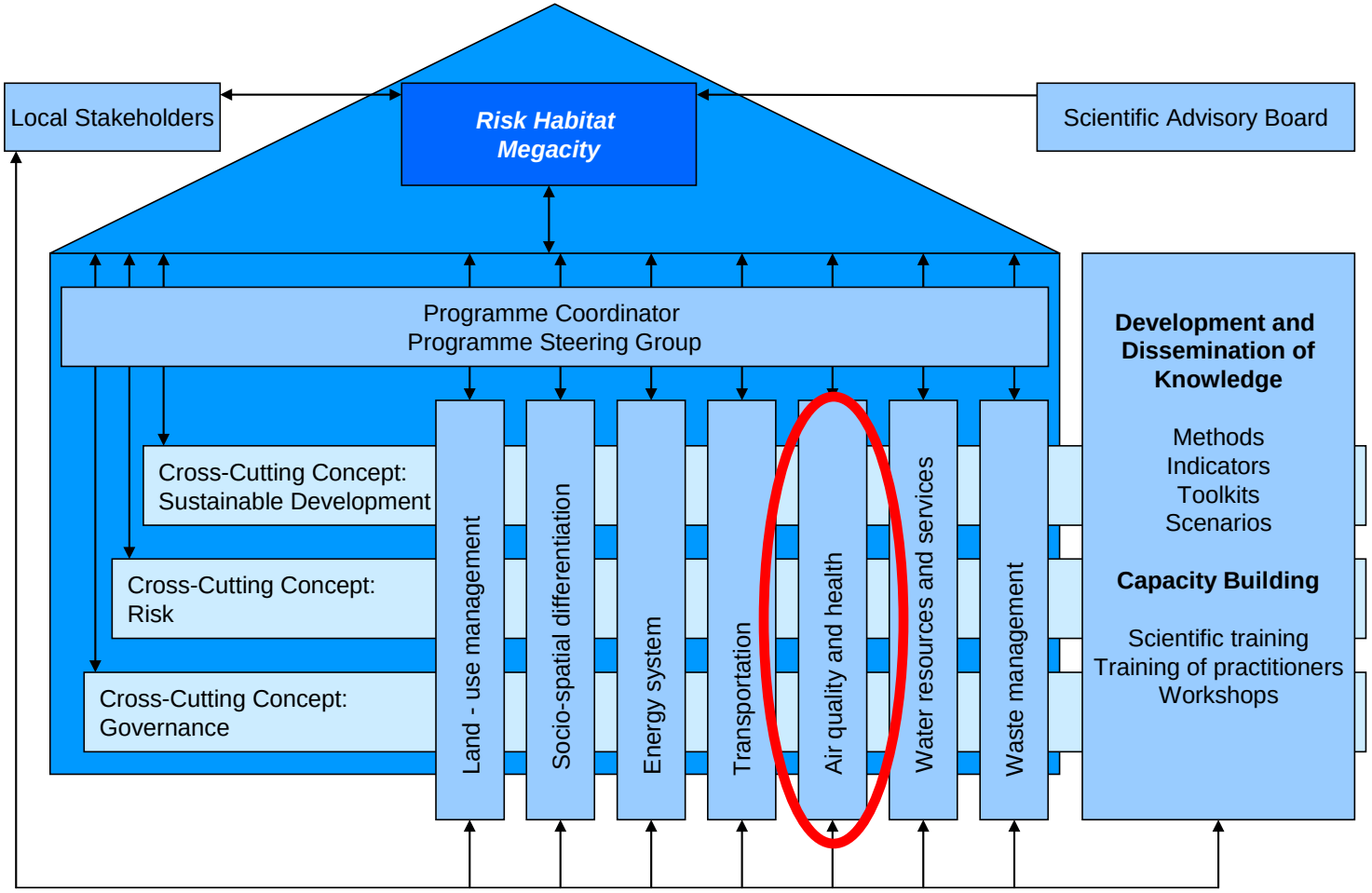


Health Impact

Stakeholder

Air Quality & Climate Change Approach

Research Project

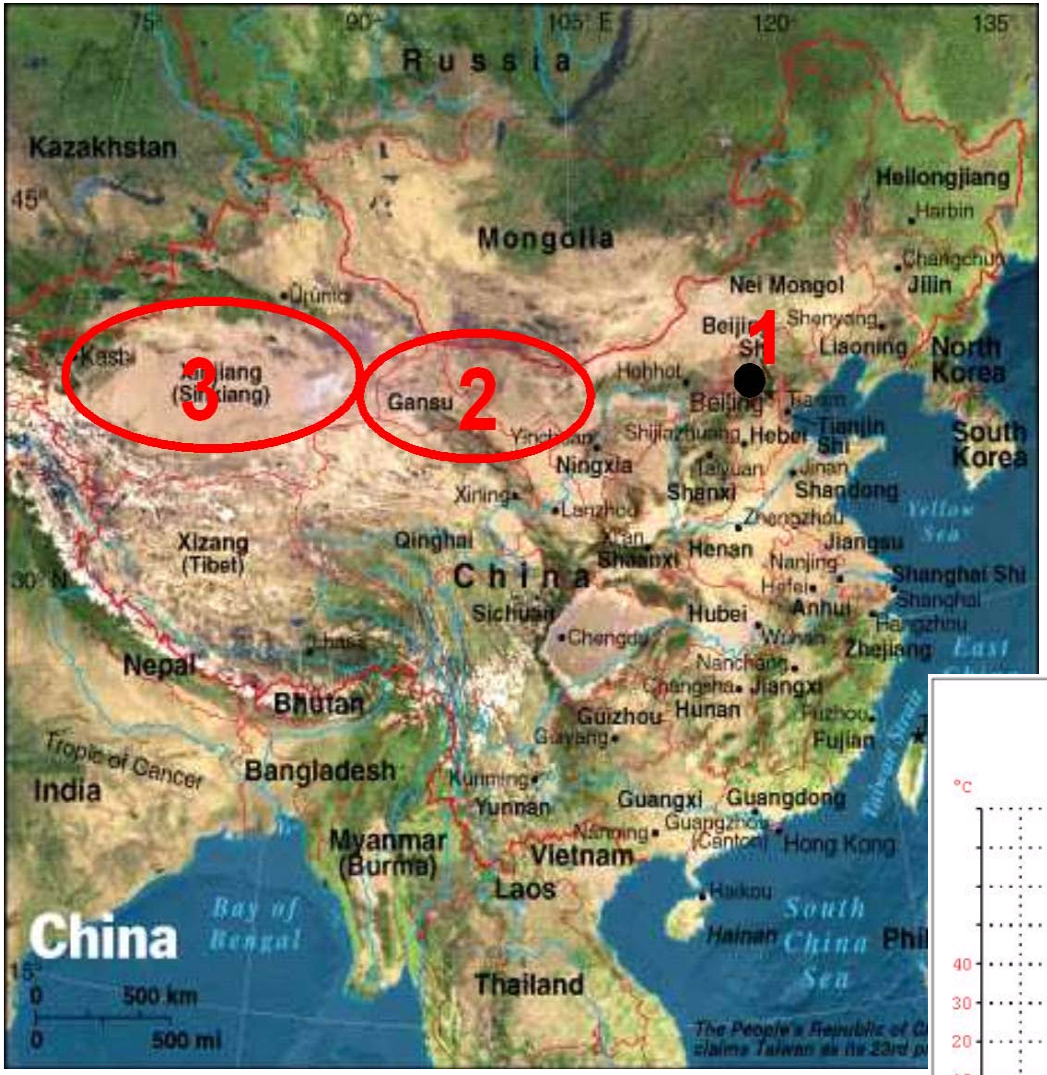


Risk Habitat Megacity
¿sostenibilidad en riesgo?

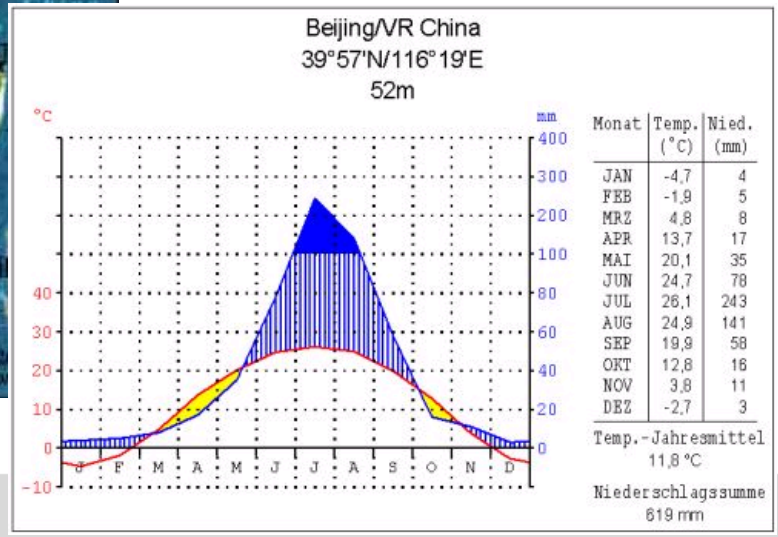
Impact on Air Quality

- Land use

Natural Land Use Change (Impact)



1: Beijing
2: Desert Gobi
3: Desert Takla Makan



Monat	Temp. (°C)	Nied. (mm)
JAN	-4,7	4
FEB	-1,9	5
MRZ	4,8	8
APR	13,7	17
MAI	20,1	35
JUN	24,7	78
JUL	26,1	243
AUG	24,9	141
SEP	19,9	58
OKT	12,8	16
NOV	3,8	11
DEZ	-2,7	3

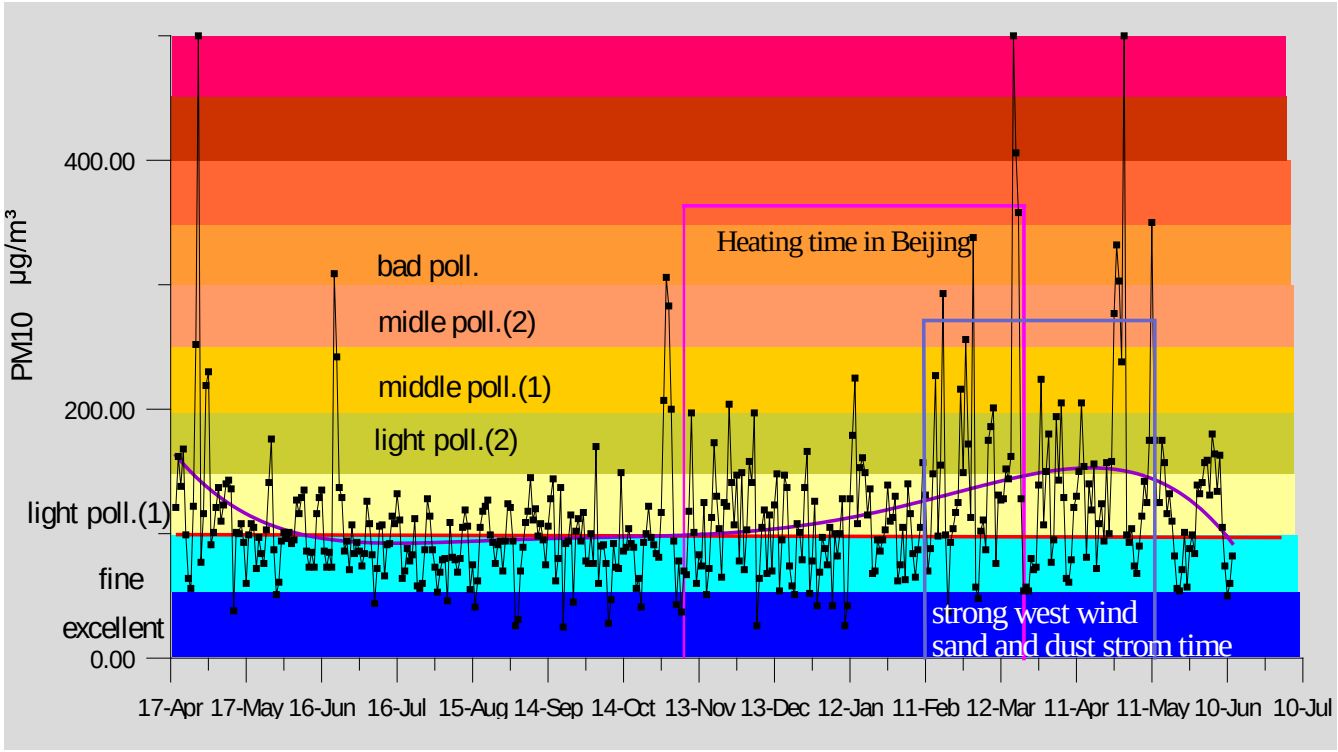
Temp.-Jahresmittel 11,8 °C

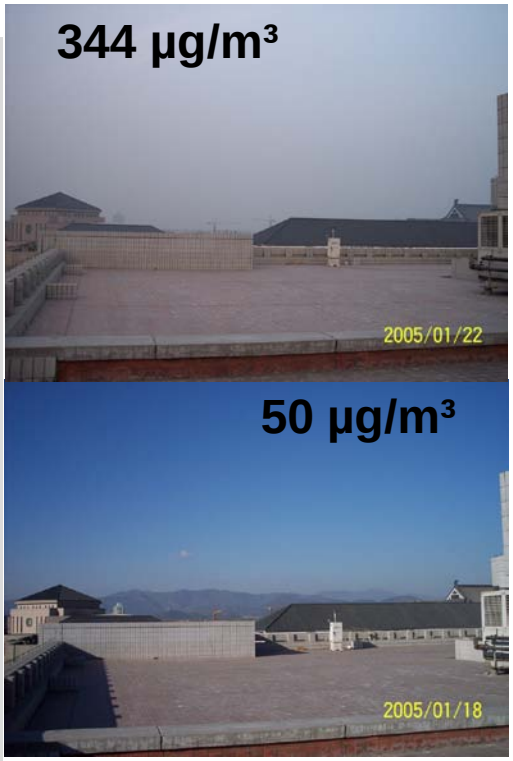
Niederschlagssumme 619 mm

Source: Stefan Norra, KIT

Aerosol Pollution

Beijing





Pictures: Matthias Tesche, IfT

Source: Stefan Norra, KIT

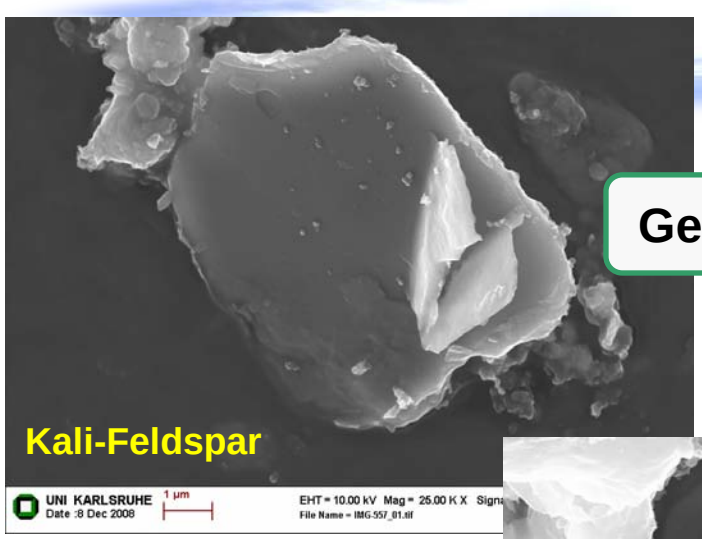
Dust Storms

Beijing

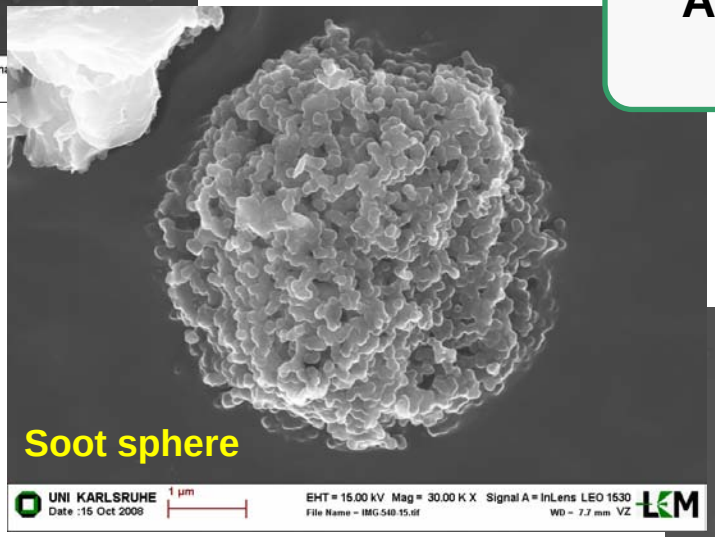
SEM Images

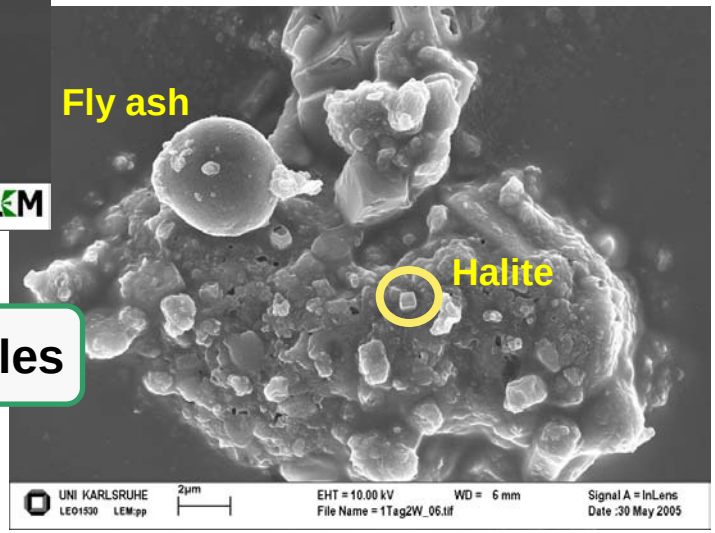
Karlsruhe Institute of Technology

Geogenic particles



Anthropogenic particles





Connected particles

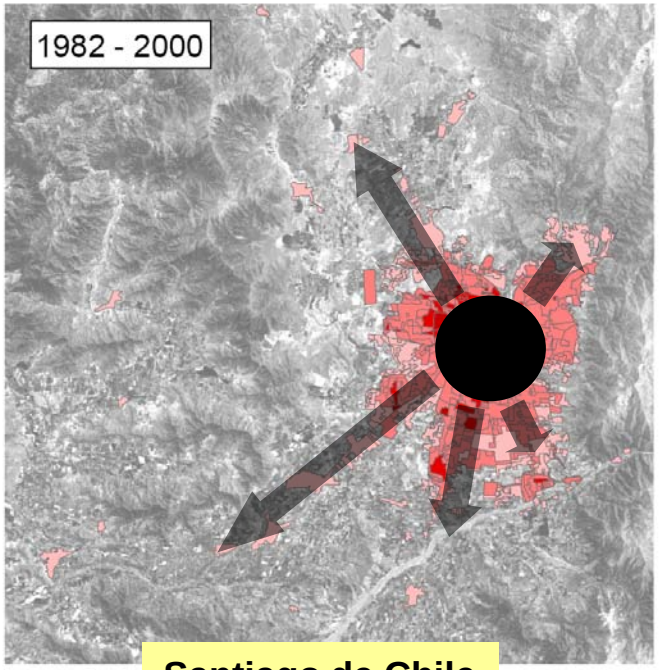
Source: Stefan Norra, KIT

Land Use Change

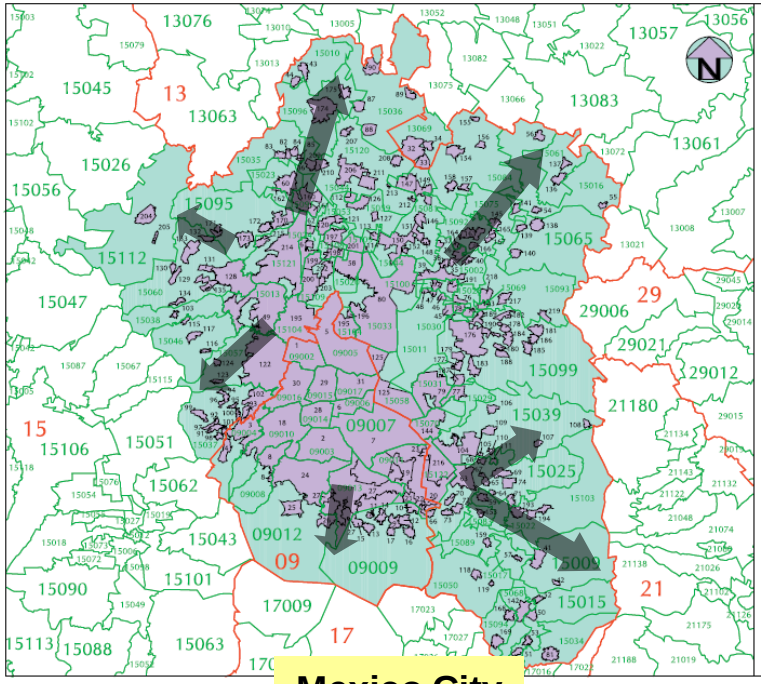
	Santiago de Chile 2002	Mexico City 2005
Population	6.061.000	19.410.000
Urbanized area (km²)	641	1800
Population density (p / km²)	9.500	10.800
Population growth (% / y)	~1,32	~1,28

Source: U. Weiland, E. Banzhaf, A. Ebert, A. Kindler, R. Höfer (UFZ)

Source:
Poduje 2005 (Santiago de Chile)
APERC 2007 (Mexico City)

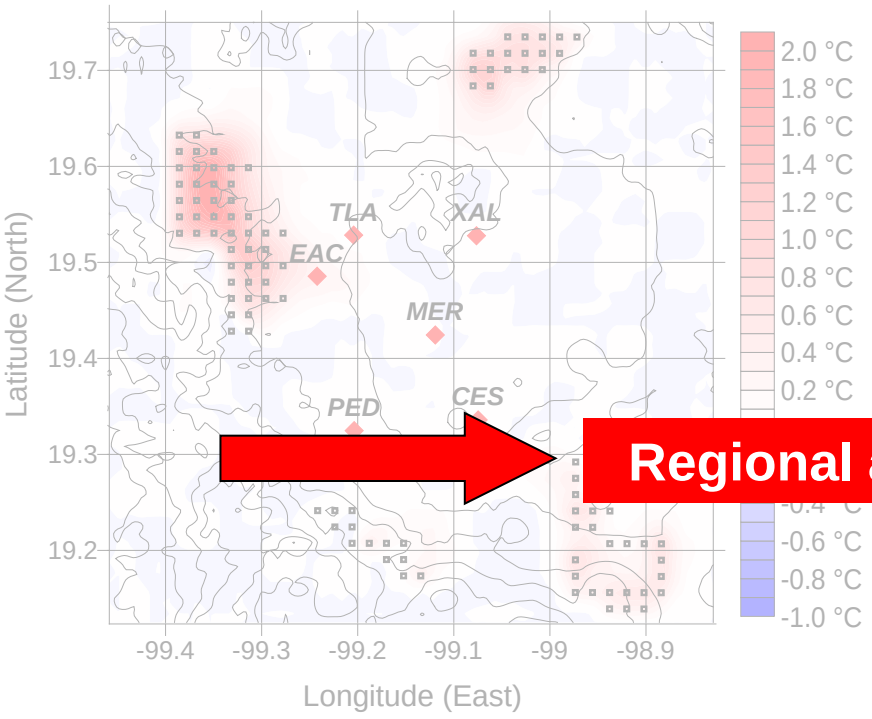


Santiago de Chile

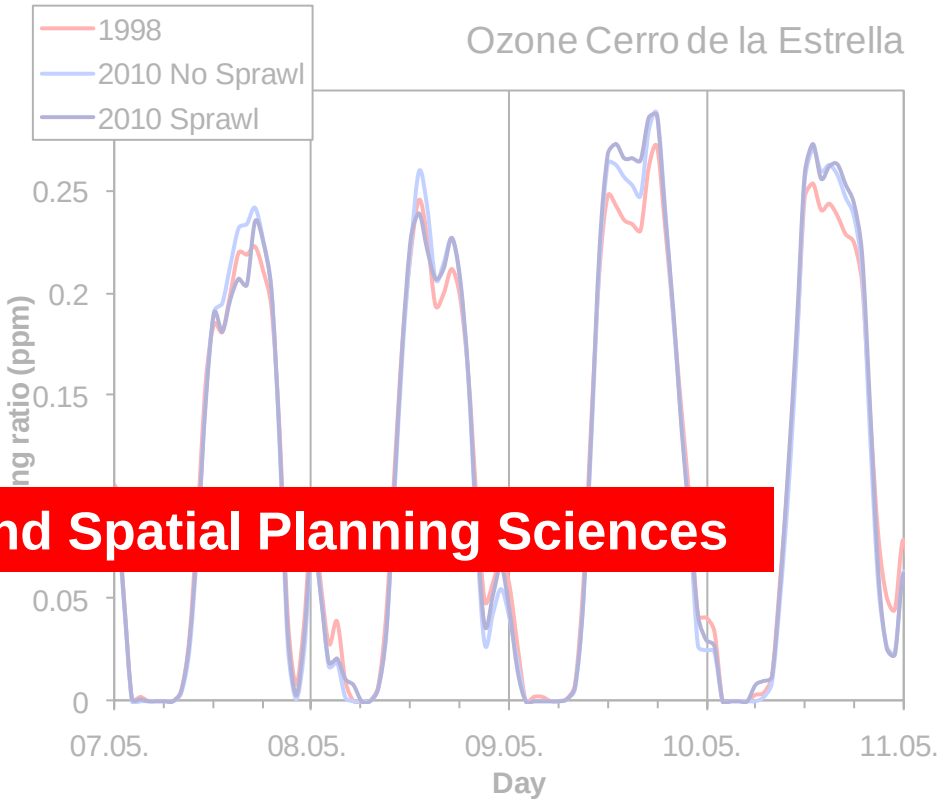


Mexico City

Effect of land use change



Temperature difference
with and without urban sprawl



Diurnal variation of ozone concentrations
considering land use change

Source: Renate Forkel (IMK-IFU)

Regional and Spatial Planning Sciences

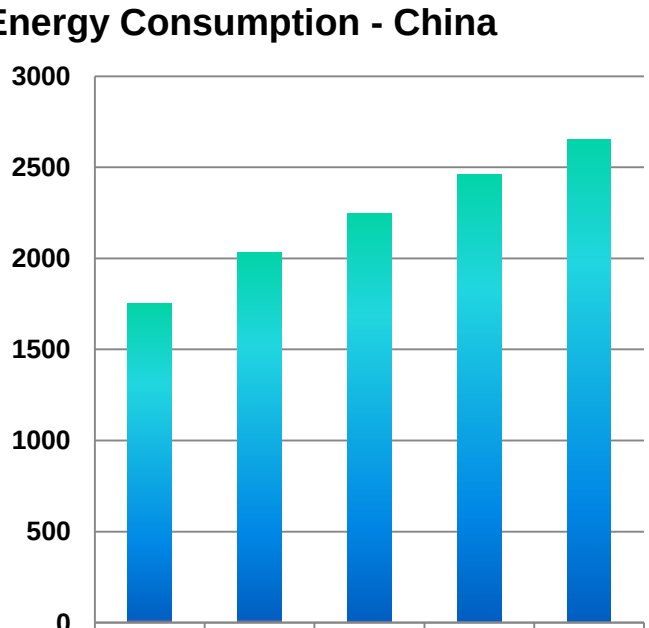
Impact on Air Quality

- Land use
- Energy

Energy Consumption

Energy consumption by sources

	Industry	Transport	Residential
Beijing	75%	8%	17%
Shanghai	83%	10%	7%
Seoul	38%	25%	37%
Tokyo	41%	37%	22%
Mexico City	38%	44%	18%

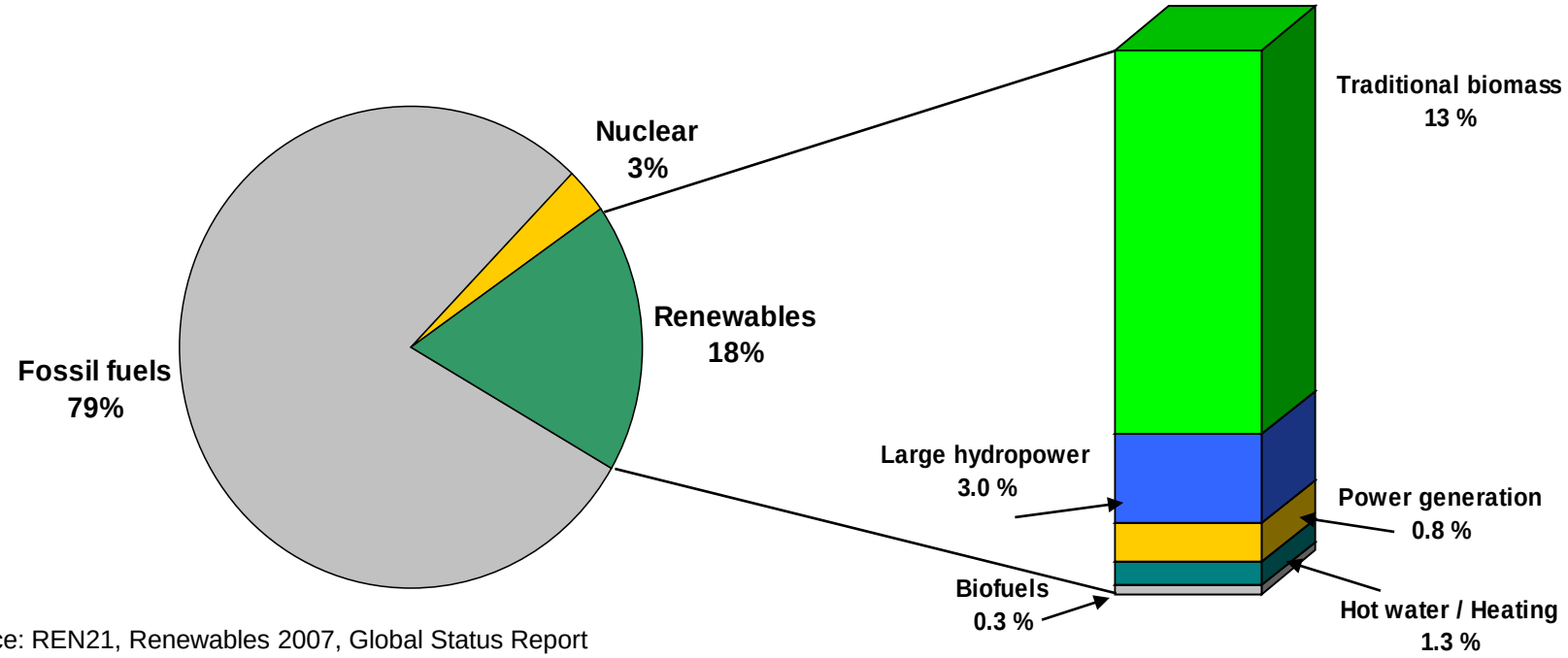


	2003	2004	2005	2006	2007
Total Energy Consumption [1 Mill. Tons CE]	1749.9	2032.227	2246.82	2462.7	2654.8
Growth Rates [%]	15.3	16.1	10.6	9.6	7.8

Source: APERC 2007, Shobhakar Dhakal (2004). Urban Energy Use and Greenhouse Gas Emissions in East Asian Megacities

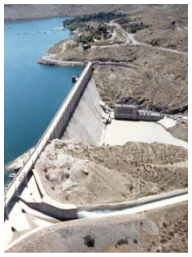
Source: China Statistical Abstract 2009

Global final energy consumption

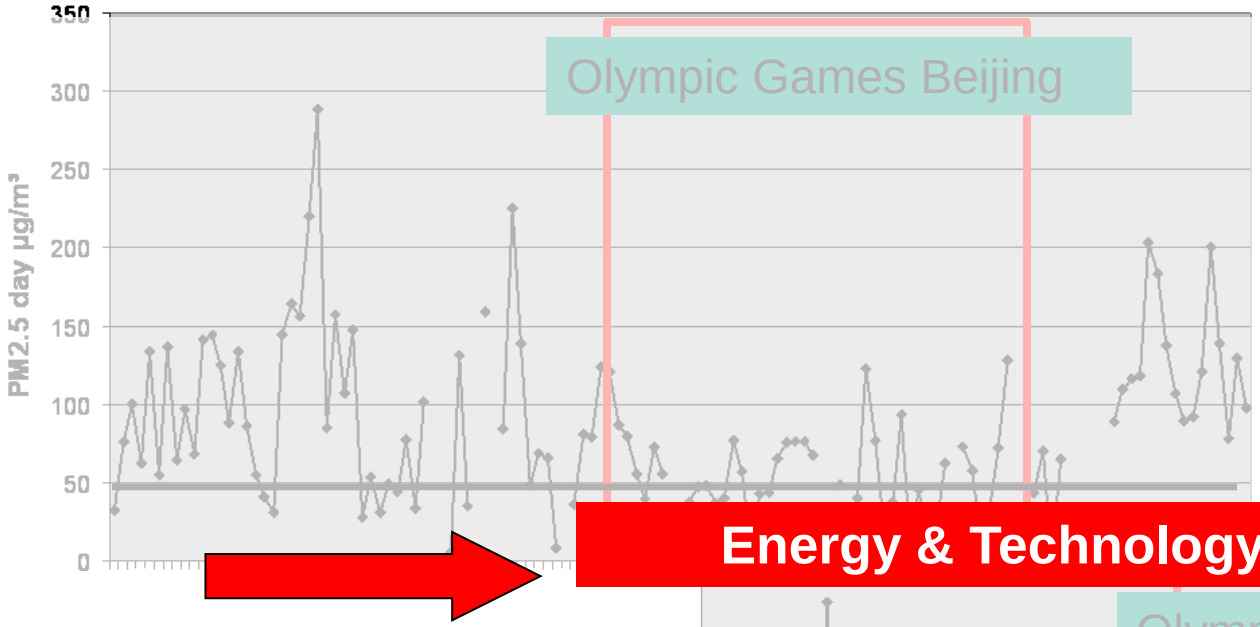


Source: REN21, Renewables 2007, Global Status Report

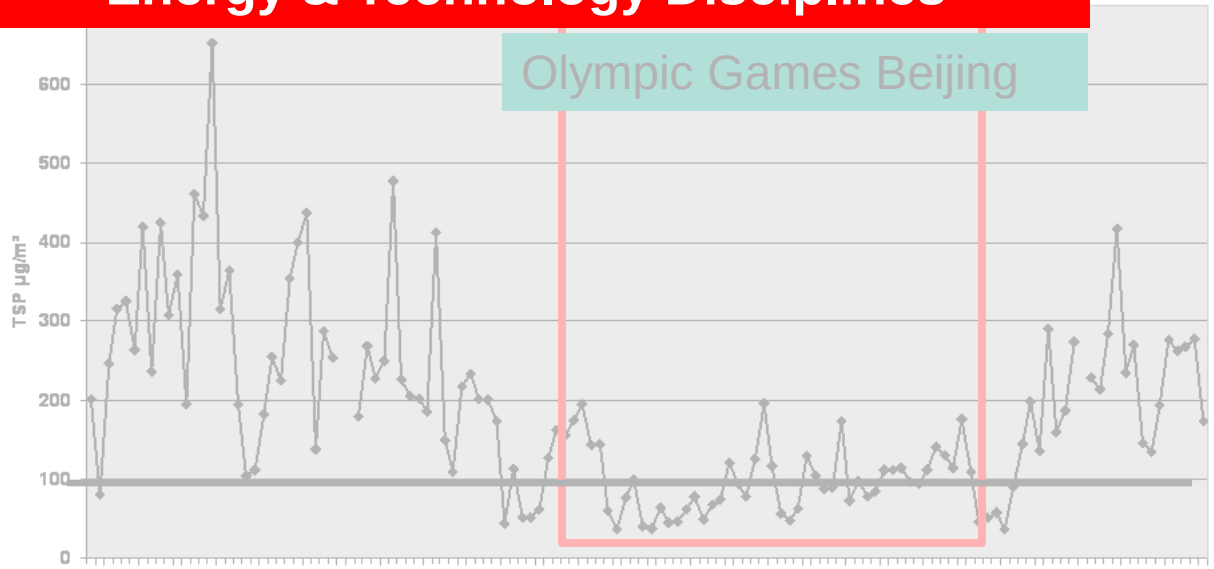


Emission Reduction Strategies



Energy & Technology Disciplines



Time Period:
15.10.2007 – 01.02.2009

Source: Stefan Norra, KIT

Impact on Air Quality

- Land use
- Energy
- Mobility

Traffic

Economical background of vehicle ownership

Vehicle purchase max GDP 3000-4000 $

Which will be reached in China in about 20 y

Traffic Volume in 1996 and 2020

Source: US Dept.of Energy, 2000

Sampling Strategies

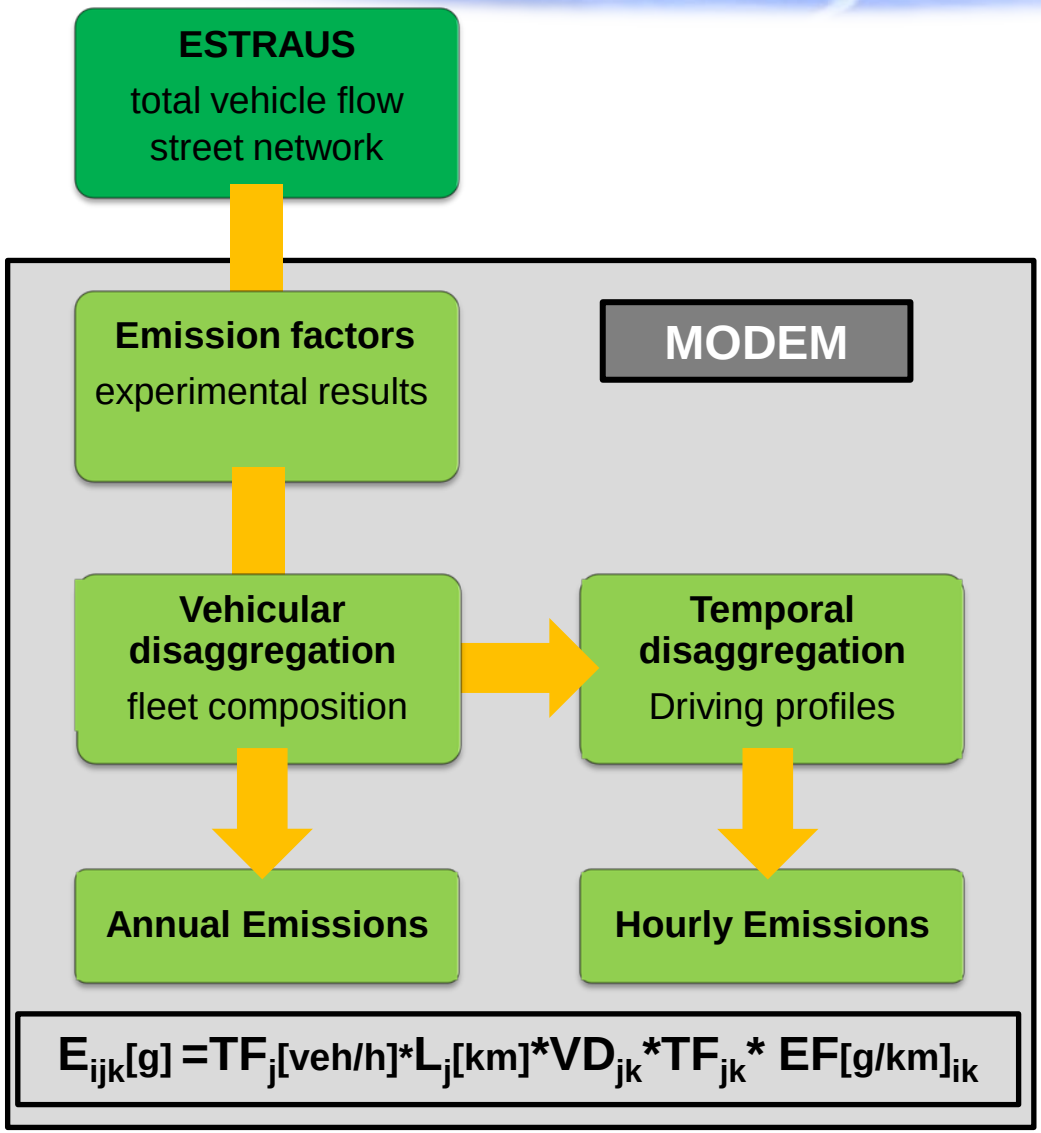
Measurement sites: LAPC tower, ceilometer, DOAS

Optical remote sensing:
Ceilometer from Vaisala LD40 or CL31
wave length: 855 or 910 nm
range: 4000 m
Resolution: 15 or 5 m

Münkel, C., “Mixing height determination with lidar ceilometers - results from Helsinki Testbed,” Meteorol. Z. 16, 451-459 (2007).

Emeis, S., Schäfer, K., Münkel, C.: Observation of the structure of the urban boundary layer with different ceilometers and validation by RASS data. Meteorol. Z. 18, 2, 149-154 (2009)

Traffic & Emission Modelling: Santiago



61 vehicle categories

Buses licitados Diesel convencional
Buses licitados Diesel tipo 1
Buses licitados Diesel tipo 2
Buses licitados Diesel tipo 3
Buses licitados DIesel tipo 3 Articulando
Buses licitados Diesel tipo 2 con filtro
Buses licitados Diesel tipo 3 con filtro
Buses Interurbanos Diesel convencional
Buses Interurbanos Diesel tipo 1
Buses Alimentador Diesel tipo 2
Buses Alimentador Diesel tipo 3
Buses Alimentador Diesel tipo 3 con filtro
.....

5 categories of emissions

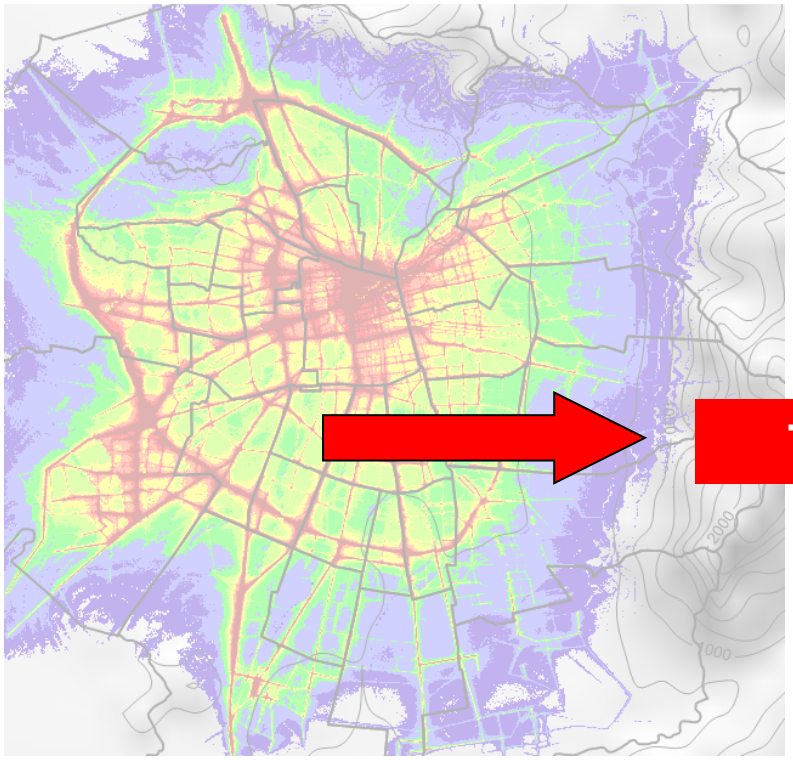
cold emissions
hot emissions
evaporation
resuspension (→ abrasion tyres, abrasion brakes)

6 emission pollutants

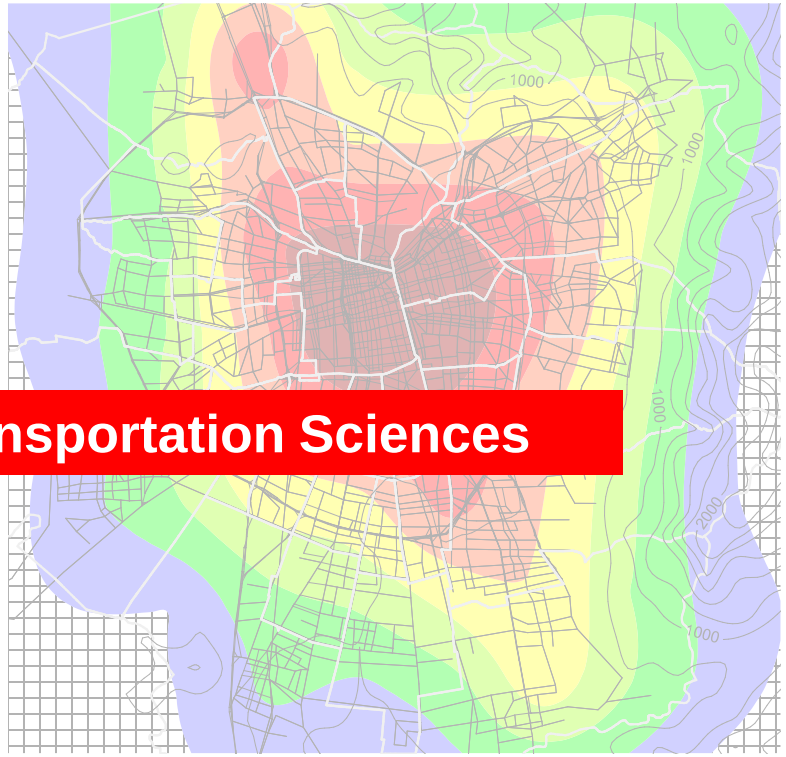
PM10
SO2
NOx
HC
CO
CO2
[Gasoline consumption]

Input data for the simulation of traffic emissions

Coupling of Scales



Transportation Sciences

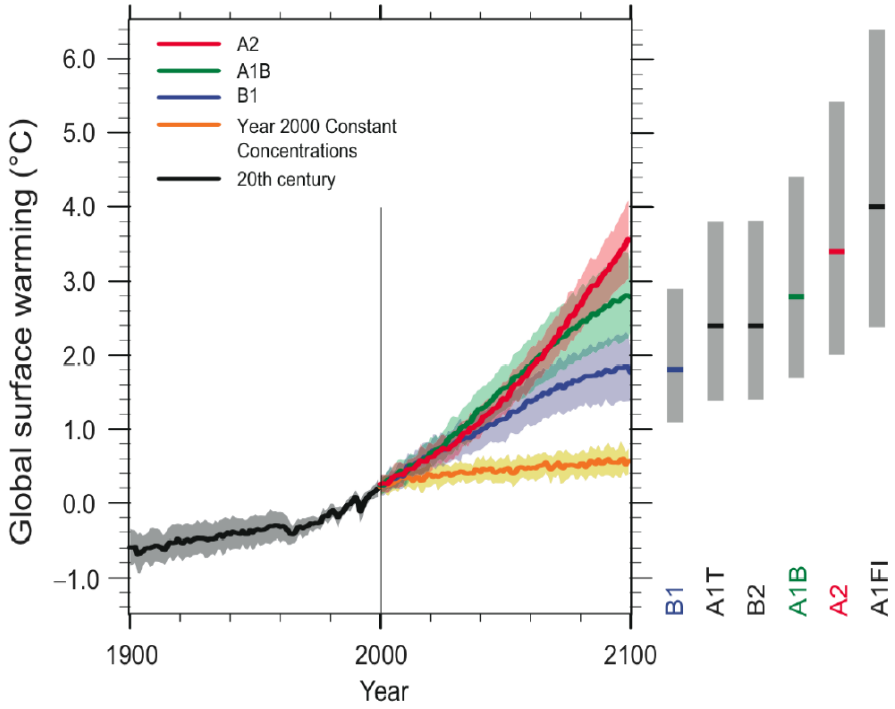


Micro-scale modelling
e.g. NO_x with GRAL

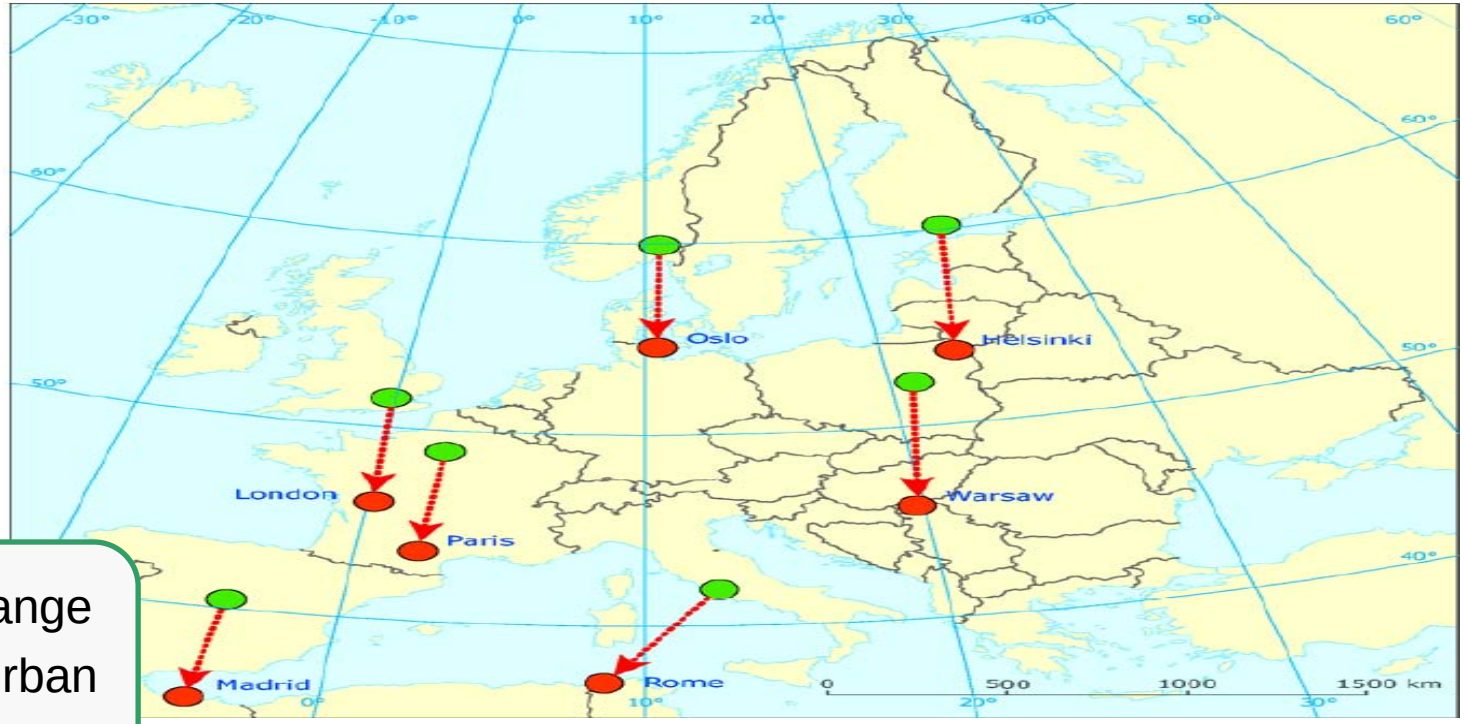
Meso-scale modeling e.g.
NO_2 with WRF/chem

Impact on Air Quality

- Land use
- Energy
- Mobility
- Climate Change



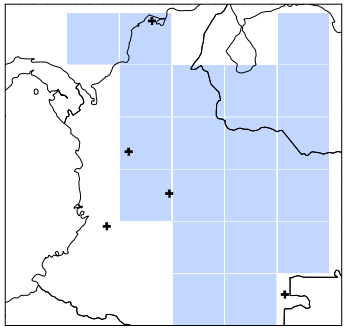
Consequences of Climate Change



Climate Change Impact on Urban Agglomerations

Kamal-Chaoui, Lamia and Alexis Robert (eds.) (2009), “Competitive Cities and Climate Change”, OECD. Regional Development Working Papers N° 2, 2009, OECD publishing.

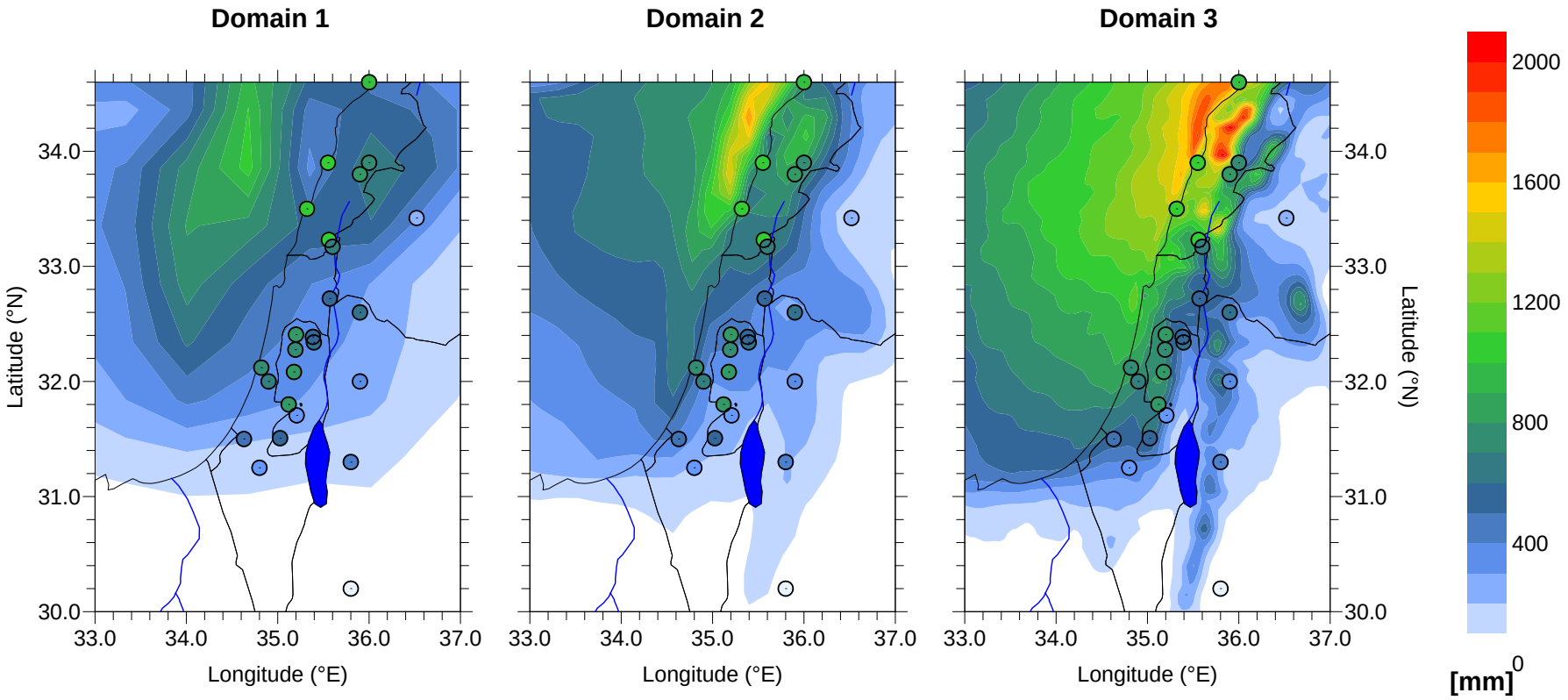
Climate Change



Climate Change
Impact on Urban
Agglomerations

Resolution too coarse for regional impact analysis !

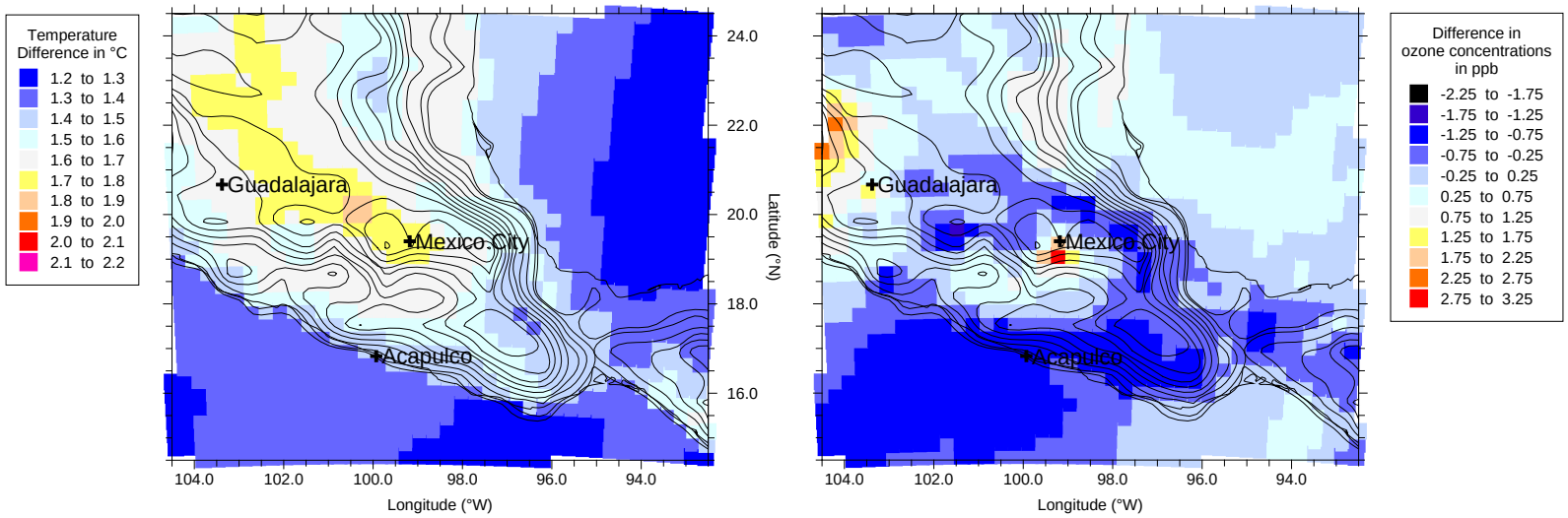
Dynamical Downscaling



Yearly Mean Precipitation 1961-1975

Validation of the simulation results by comparing simulated observed precipitation

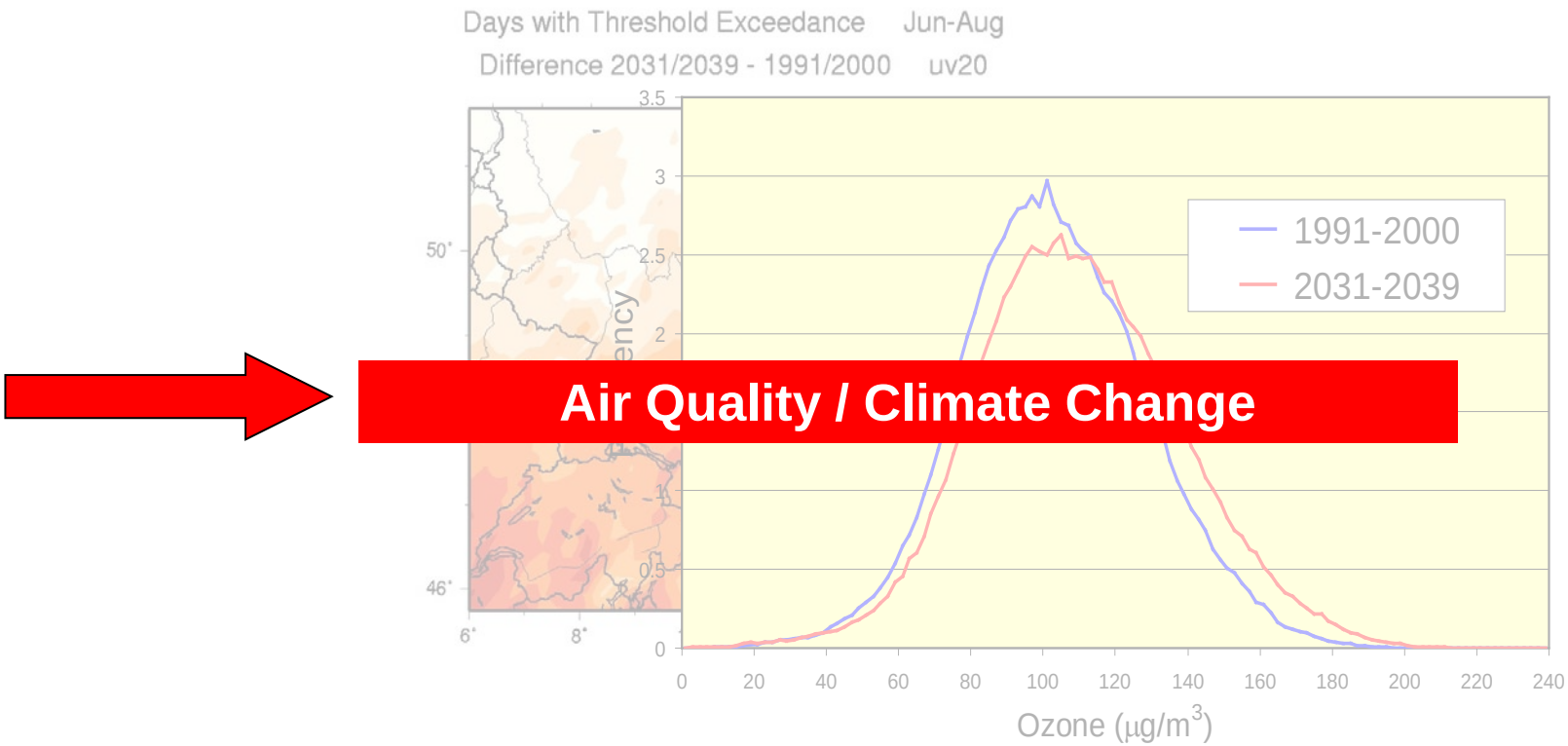
Regional Climate Change Impact



High resolution climate-chemistry simulations
- Mexico -

Source: Renate Forkel (IMK-IFU)

Regional Climate Change Impact



Air Quality / Climate Change

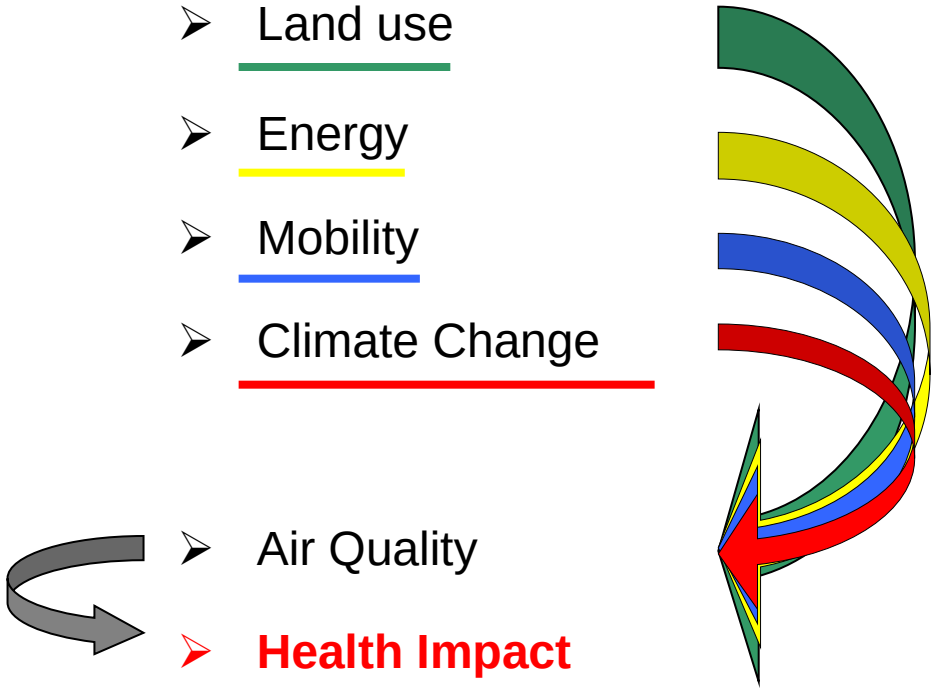
Threshold exceedances in the future

Distribution of daily O_3 maximum

Source: R. Forkel (IMK-IFU)

Impact on Air Quality

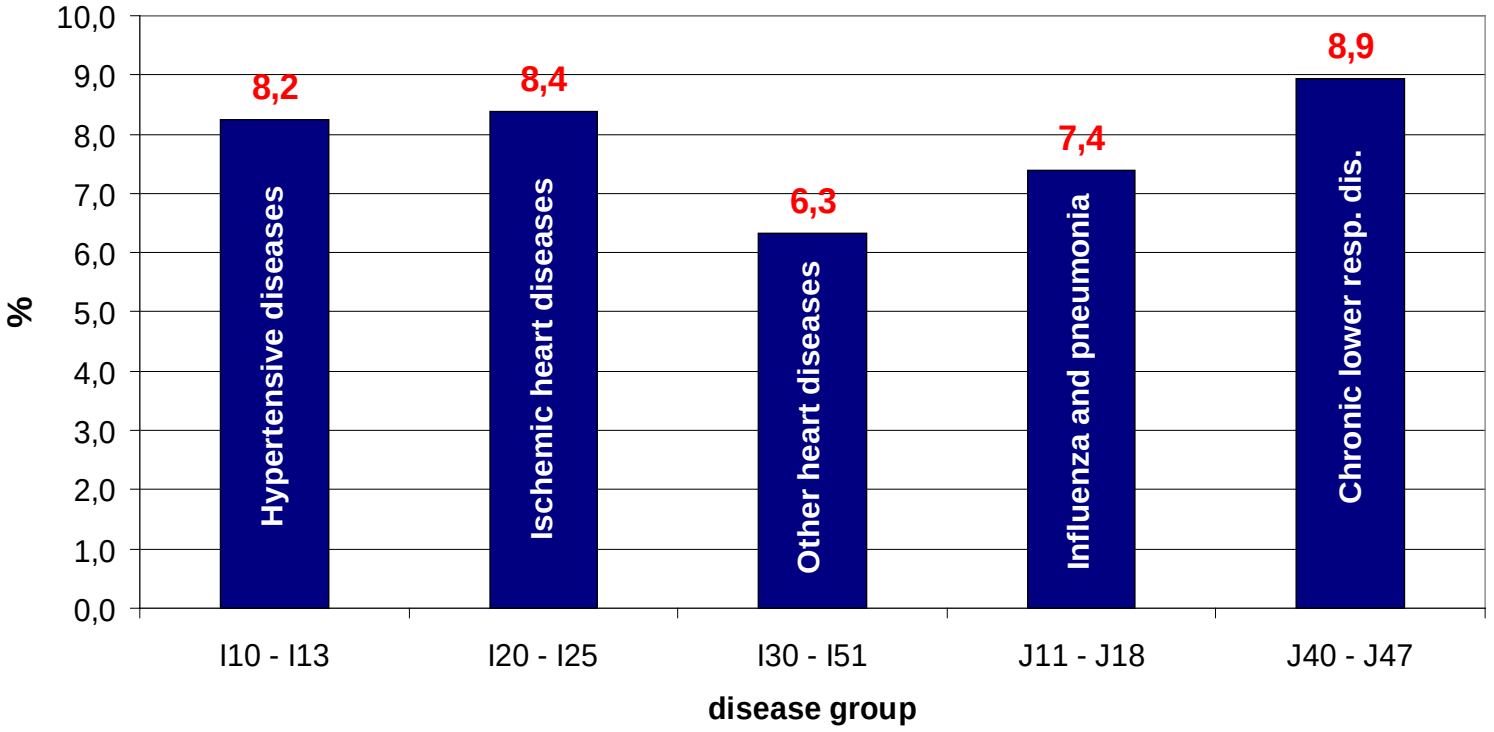
- Land use
- Energy
- Mobility
- Climate Change



- Air Quality
- **Health Impact**

Integrated Approach

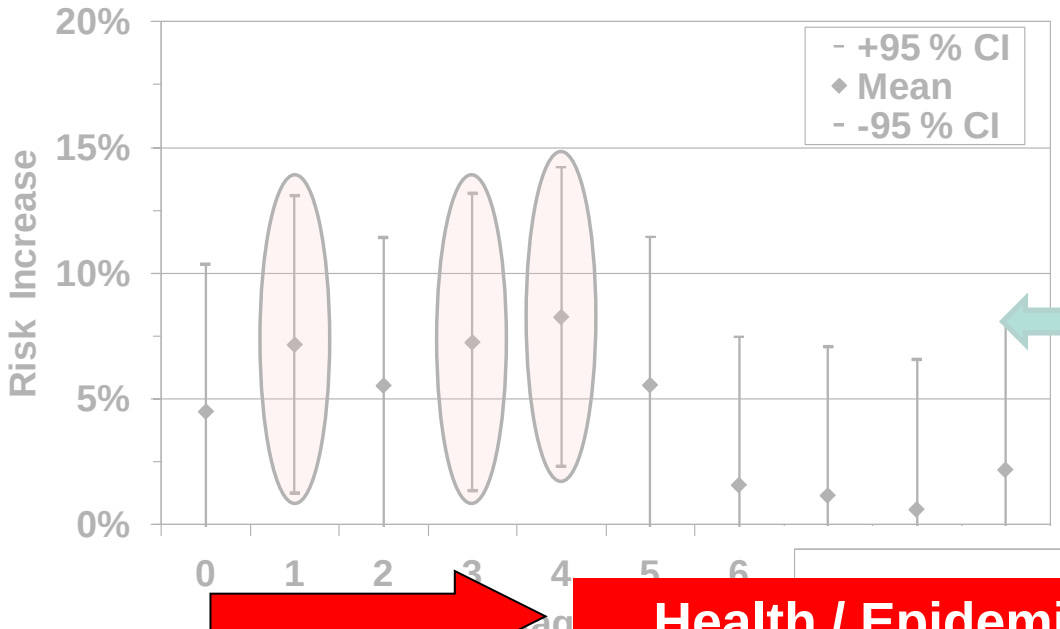
Adverse Health Effects: Santiago



Source: Ulrich Franck, UFZ

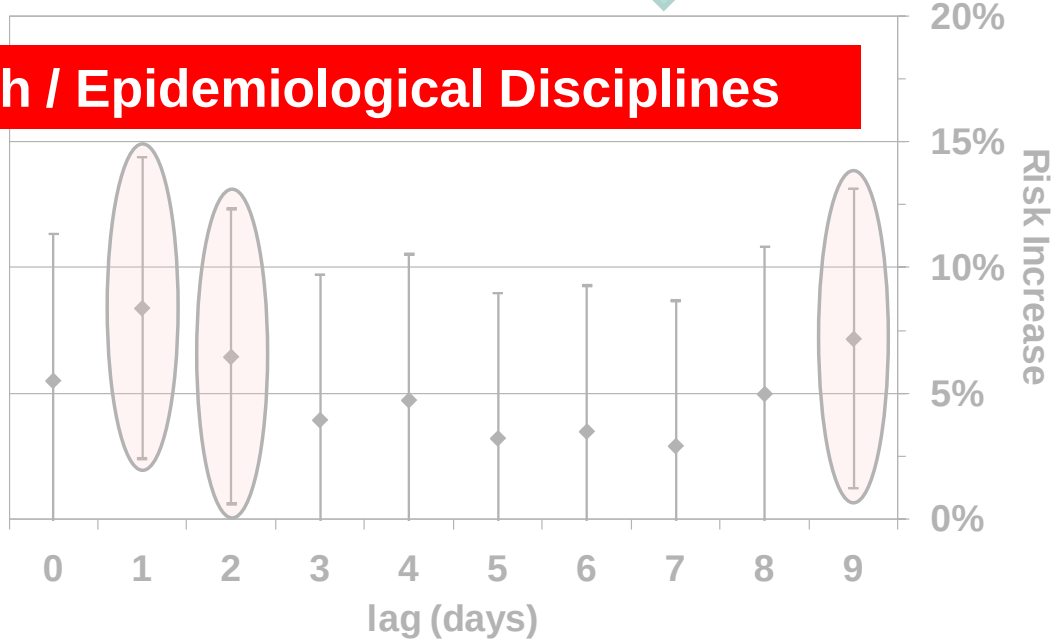
Maximum Mortality Risks per 10 µg/m³ PM_{10}

Adverse health effects of PM_{10} in 2006



Lagged risk increase per 10 µg/m³ PM10 for hypertensive (left) and ischemic heart diseases (below).

Health / Epidemiological Disciplines



Source: Ulrich Franck, UFZ

Conclusions

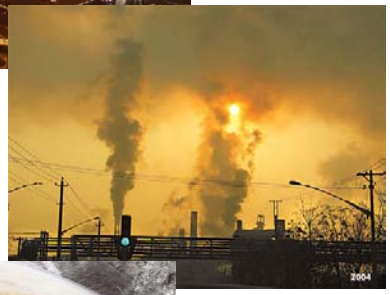
- Air quality & Climate Change issues need an holistic and multidisciplinary approach
- Strong links to
  - **Regional and Spatial Planning Sciences**
  - **Energy & Technology Assessment Disciplines**
  - **Transportation Sciences**
  - **Health / Epidemiological Disciplines**
  - **Social Sciences**
- Link between these fields tackles central problems in mega cities
- Complex system of mega cities, needs further process studies in each discipline
- Air quality and health impact assessment studies are essential prerequisites for mitigation and adaptation strategies and for reducing e.g.
  - environmental risks (air pollution, climate change impact, congestion, waste, ...)
  - social risks (spatial segregation, health problems, …)
  - costs (healthcare system, transportation, production, ...)

Co-operations and Partners

- **Chinese Academy of Sciences (CAS), Beijing**
  - Prof. Yuesi Wang
  - Dr. Xin Jinyuan
- **China University of Geosciences (CUG), Beijing**
  - Prof. Kuang Cen
- **China University of Mining and Technology, Beijing (CUMTB)**
  - Prof. Longyi Shao
- **Chinese Research Academy of Environmental Sciences (CRAES), Beijing**
  - Prof. Chai Fahe
  - Prof. Chen Yizhen
- **German Meteorological Service (DWD), Freiburg**
  - Dipl.-Ing. Volker Dietze
  - Dipl.-Ing. Mathieu Fricker
- **Helmholtz Center Munich (HMGU)**
  - Prof. Dr. Annette Peters
  - Dr. Jürgen Schnelle-Kreis
- **Qingdao Research Academy of Environmental Sciences (QRAES)**
  - Prof. Sun Hekun

? **School of Public Health, Peking University, Beijing**

- Prof. Xiao-chuan Pan



Capacity Building

in cooperation with Prof. Longyi Shao (CUMTB), Prof. Kuang Cen (CUG) and Prof. Yuesi Wang (CAS-IAP)

Rongrong Shen, full CSC PhD Student (4 years)

- aerosol measurements with the focus on source apportionment

Ruiguang Xu, full CSC PhD Student (4 years)

- air quality modeling with the focus on aerosol composition and distribution

Ling Hong, sandwich (IAP-CSC) PhD Student (4 years)

- air quality measurements with the focus on remote sensing techniques (SODAR, contactless)

Yu Yang, full CSC PhD Student (1 year)

- aerosol measurements with the focus on source apportionment / optical depth

Thank you very much for your attention

….and thank you for being here and welcome to Germany