

Air Quality in Megacities as a challenge for interdisciplinary research

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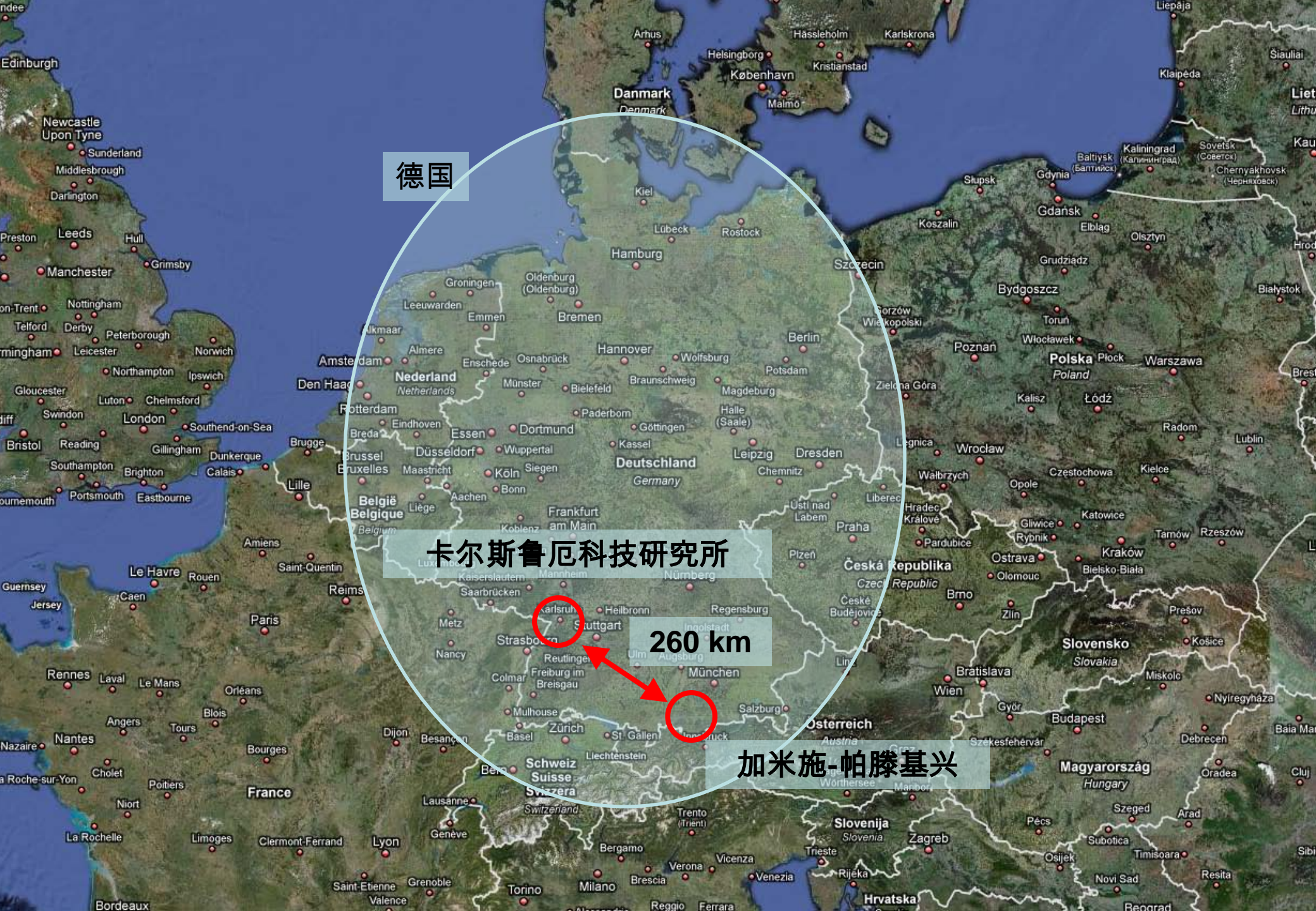
peter.suppan@imk.fzk.de

Overview

- ✓ Introduction
- ✓ Facts, problems and risks of urban agglomerations
- ✓ Methodological approach in the field of air quality
- ✓ Results

What's KIT ?

卡尔斯鲁厄科技研究所 (KIT) 介绍



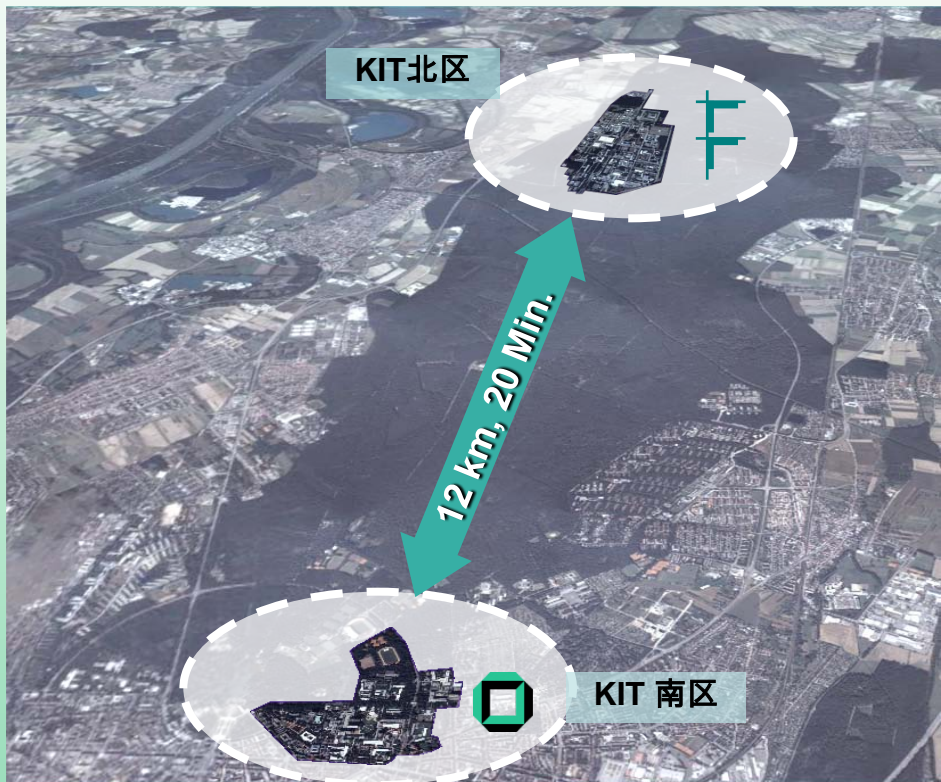
德国

卡尔斯鲁厄科技研究所

260 km

加米施-帕滕基兴

卡尔斯鲁厄科技研究所




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

+

自然和工程科学

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

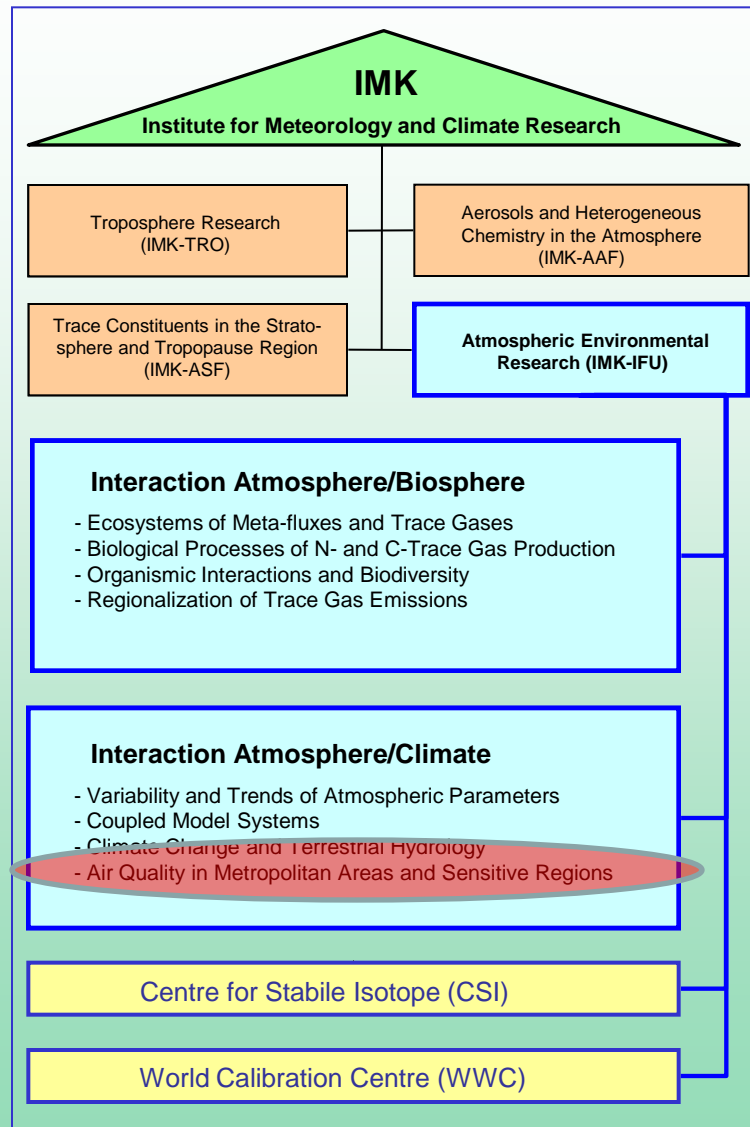


卡尔斯鲁厄气象与气候研究所
- KIT 阿尔卑斯区 -

Institut für Meteorologie und
Klimaforschung (IMK-IFU)
- KIT Campus Alpin -

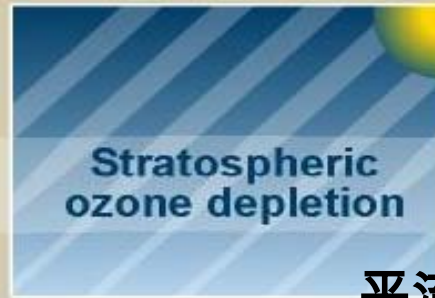


Institute



Atmospheric Research

大气环境研究



平流层臭氧损耗

空气质量



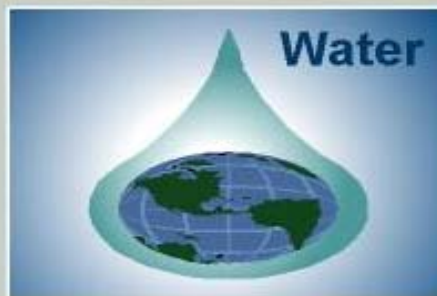
生物多样性



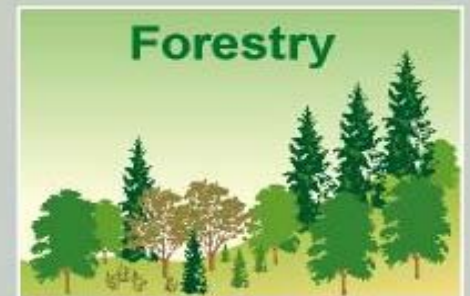
沙漠化



水



森林



Climate Change

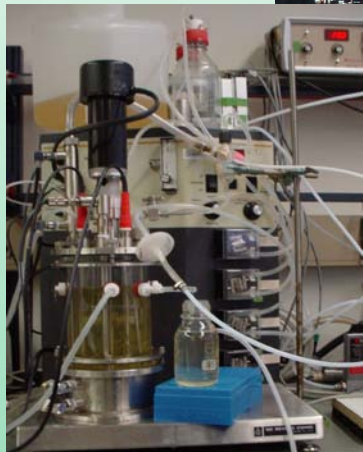
气候变化



(source: IPCC 2001, WG1 Report, Summary)

(来源：IPCC2001, WG1报告, 摘要部分)

挑战



有机个体
(实验室测定)



小区尺度
(箱法观测)



生态系统尺度
(塔观测/遥感)



区域尺度
(机载测量)



全球尺度
(遥感)

IMK-IFU Investigations

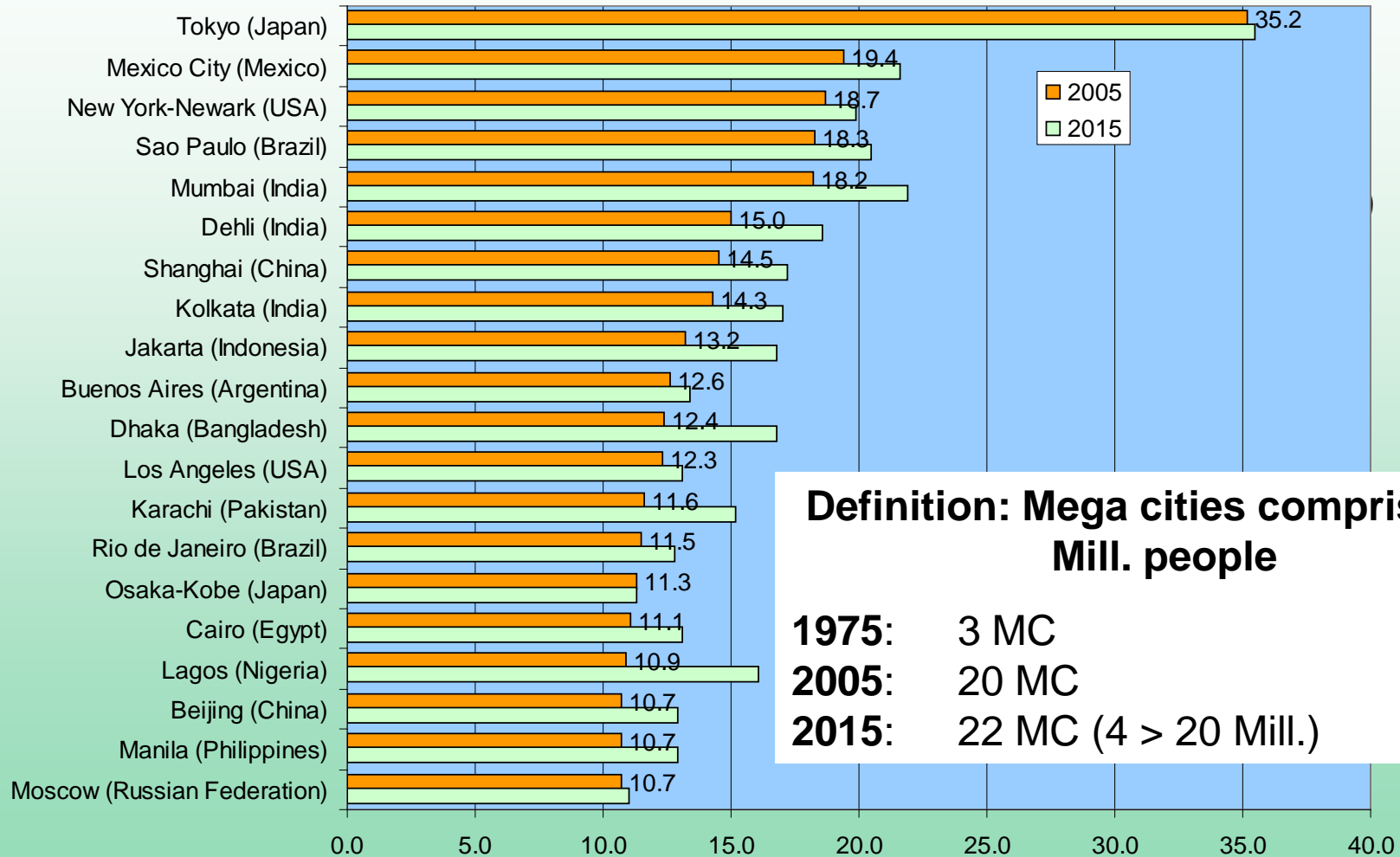
IMK-IFU 研究范围



Air Quality in Metropolitan Areas and Sensitive Regions

- Interactions between urban/suburban/rural regions and their feedback mechanism to the air quality
- Impact of regional climate change on air quality
- Developing and validation of innovative measuring techniques for the assessment of the air quality (e.g. urban agglomerations – close cooperation with epidemiologists)
- Coupling of models (e.g. MCCM, WRF-Chem, micro scale models)
- Real-time forecast of gas and particle phase pollutants
- Assessment of emission strategies (e.g. source attribution)
- Project “Risk Habitat Megacity” with the topic “Air Quality and Health”; anchor city Santiago de Chile in co-operation with Universidad de Chile

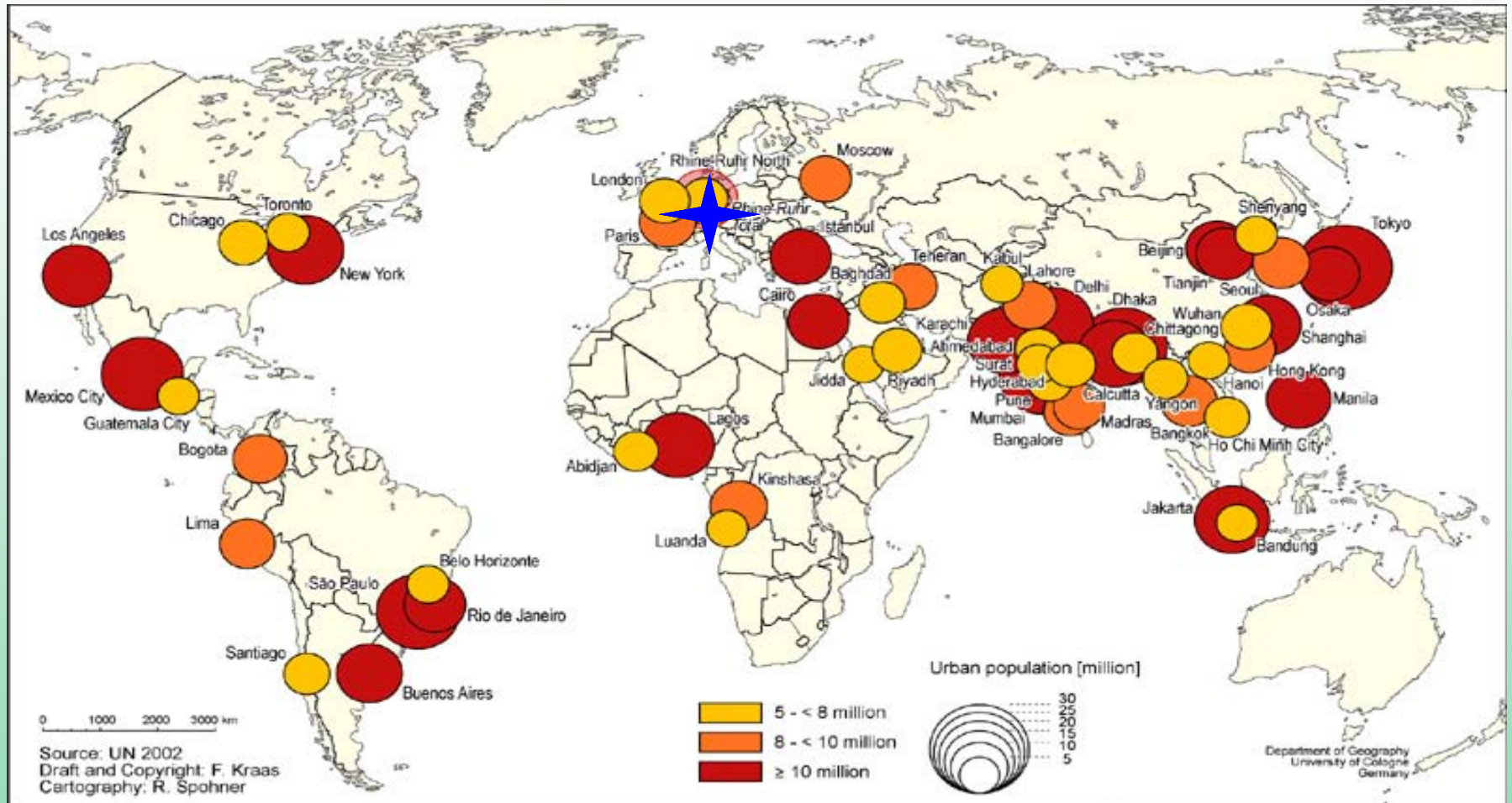
Mega Cities



Definition: Mega cities comprises 10 Mill. people

1975: 3 MC
2005: 20 MC
2015: 22 MC (4 > 20 Mill.)

Geographical Situation



Air pollution as the most significant environmental challenge,
followed by congestion issues
(Survey with 500 megacity - „stakeholders“)

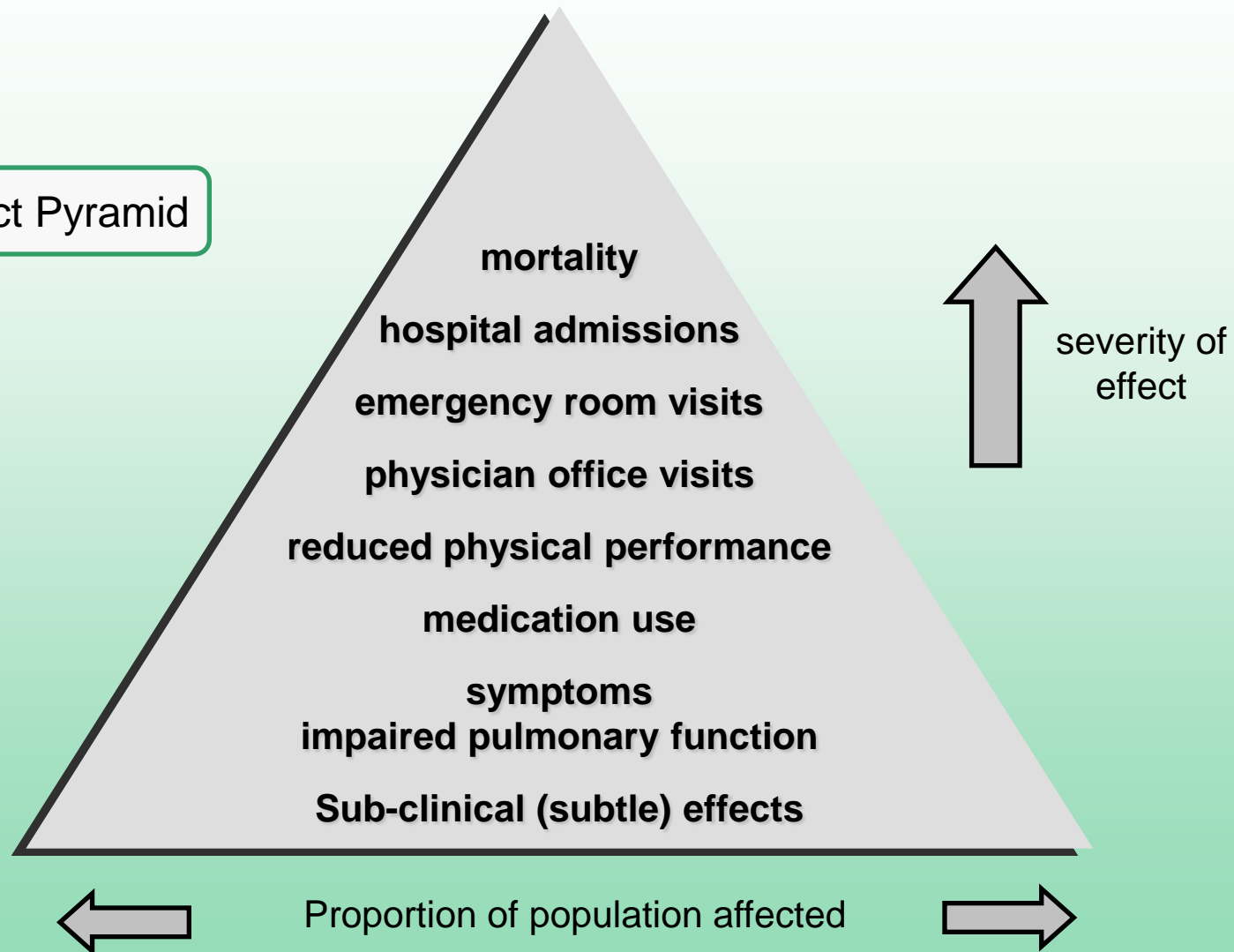
but

„The environment matters, but may be sacrificed for growth“

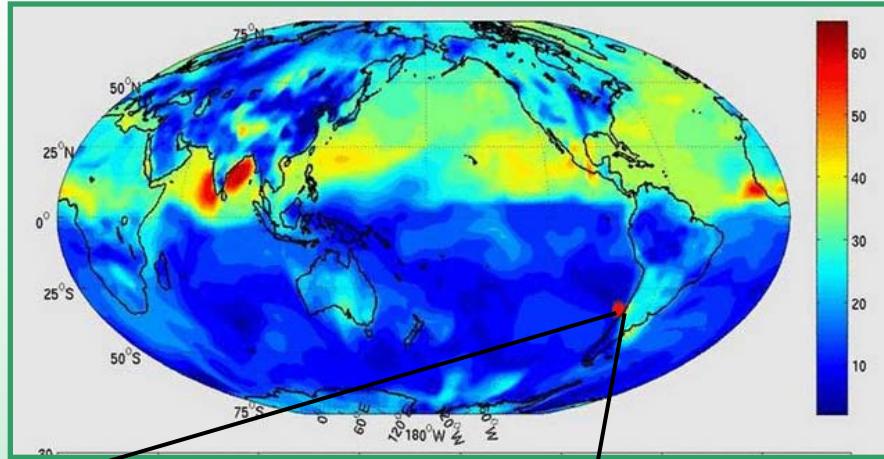
Source: Siemens, 2007

Problem: Health Impact

Health Impact Pyramid



Problem: Scales



Scales

Global

Regional

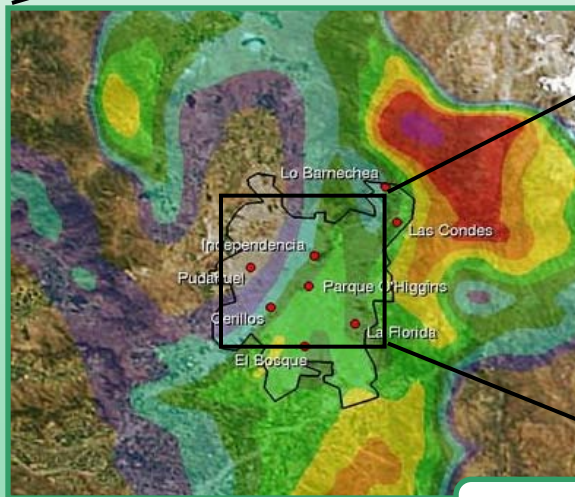
Local

Pollutants

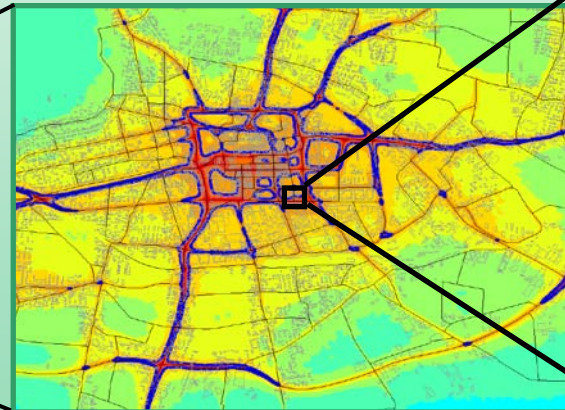
GHG, O₃

O₃, PM_{2.5}

PM, NO₂, CO



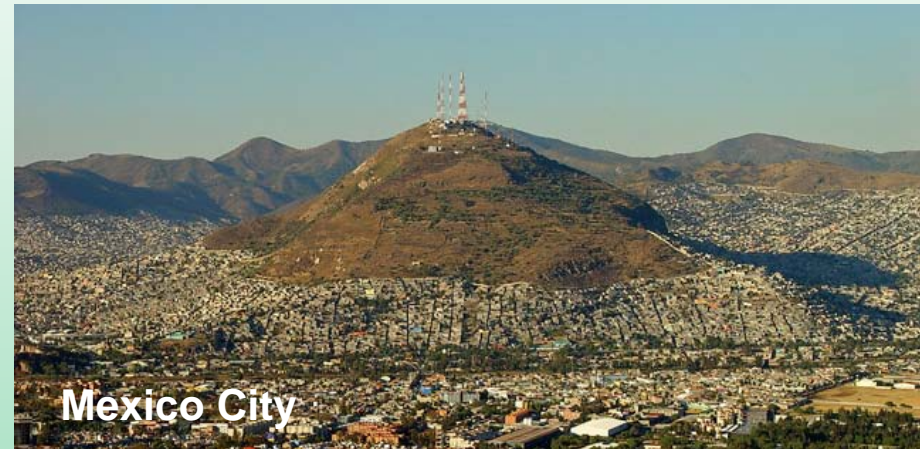
Models



Measurements

Problems and Risks

➤ Land use



31.10.2007



30.10.2007

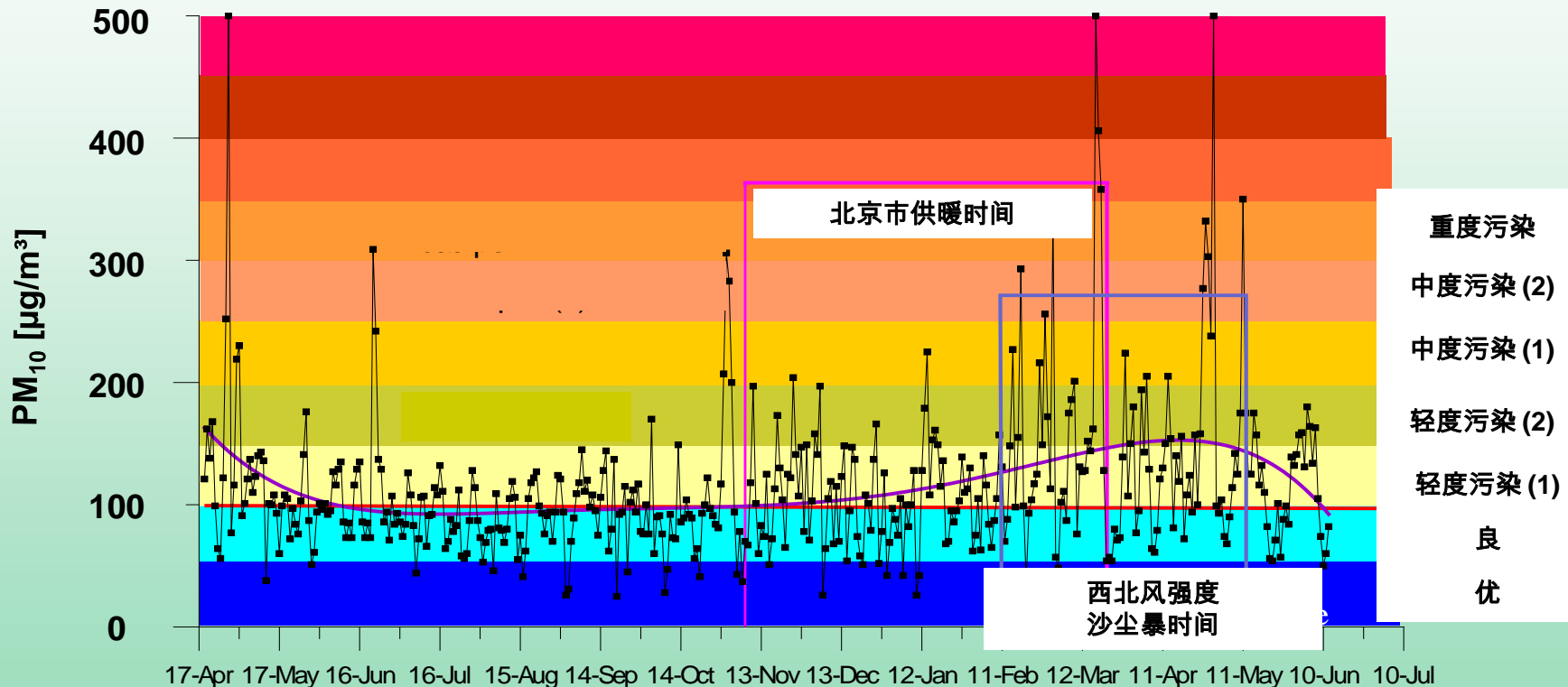


Beijing

Photos by Stefan Norra
Institute of Mineralogy and Geochemistry (IMG)
of the University of Karlsruhe

气溶胶污染

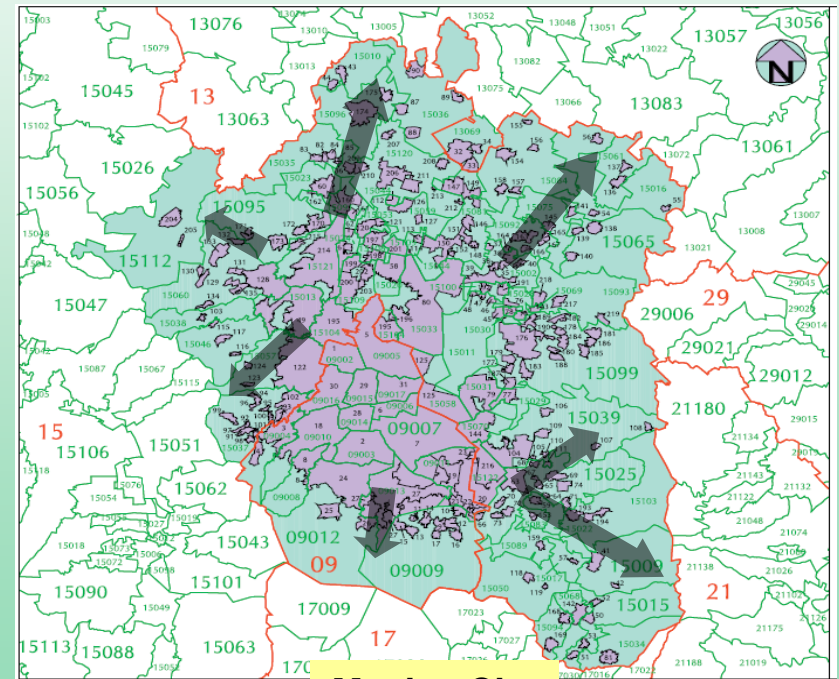
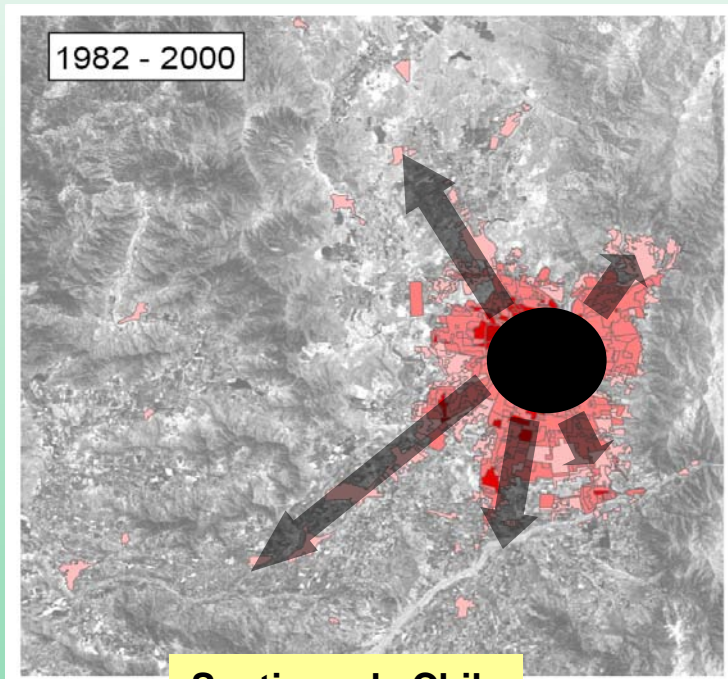
北京



Land Use Change

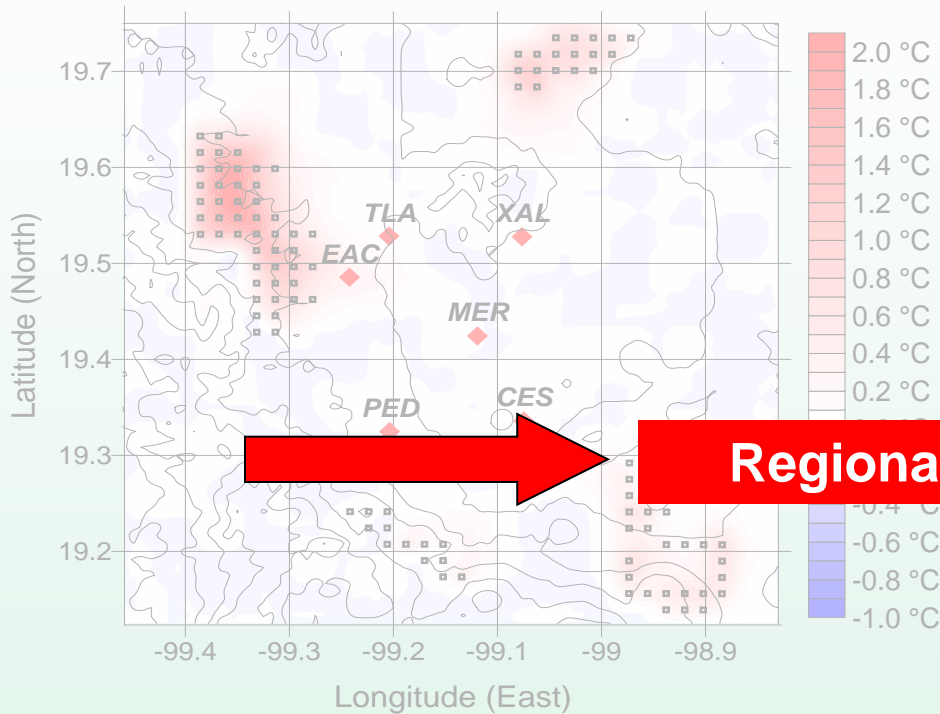
	Santiago de Chile	Mexico City
	2002	2005
Population	6.061.000	19.410.000
Urbanized area (km ²)	641	1800
Population density (p / km ²)	9.500	10.800
Population growth (% / y)	~1,32	~1,28

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

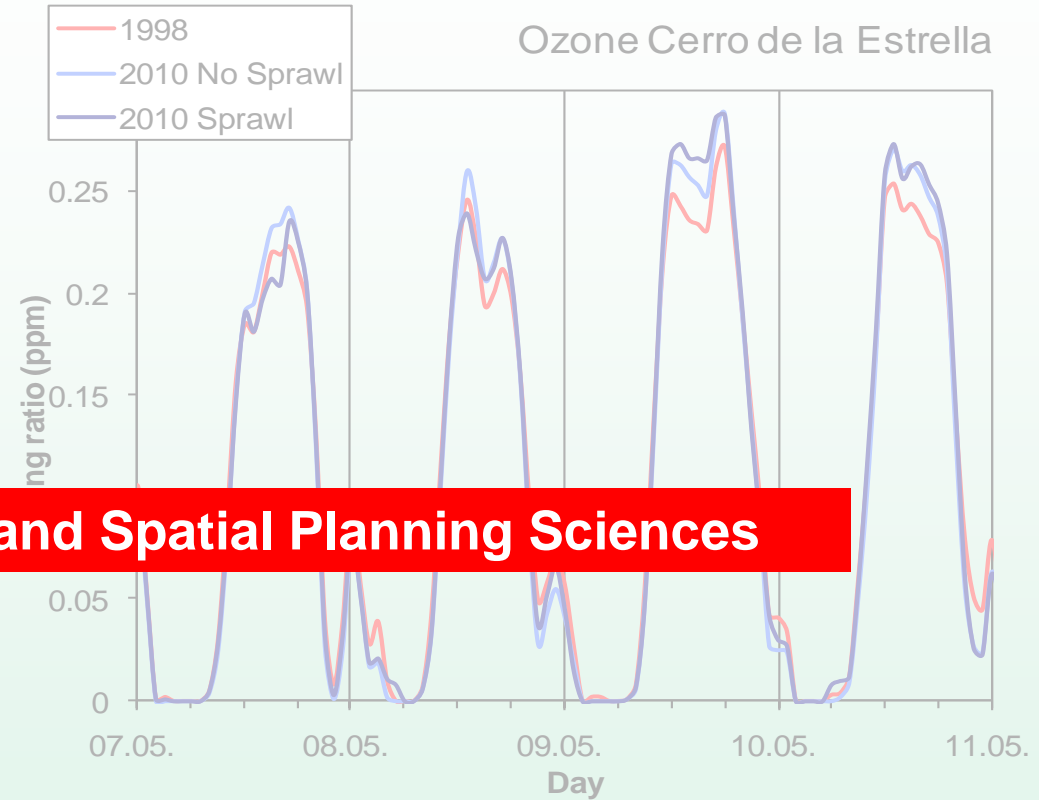


Source: U. Weiland, E. Banzhaf, A. Ebert, A. Kindler, R. Höfer (UFZ)

Effect of land use change



Temperature difference with and without urban sprawl



Diurnal variation of ozone concentrations considering land use change

Regional and Spatial Planning Sciences

Problems and Risks

- Land use
- Energy

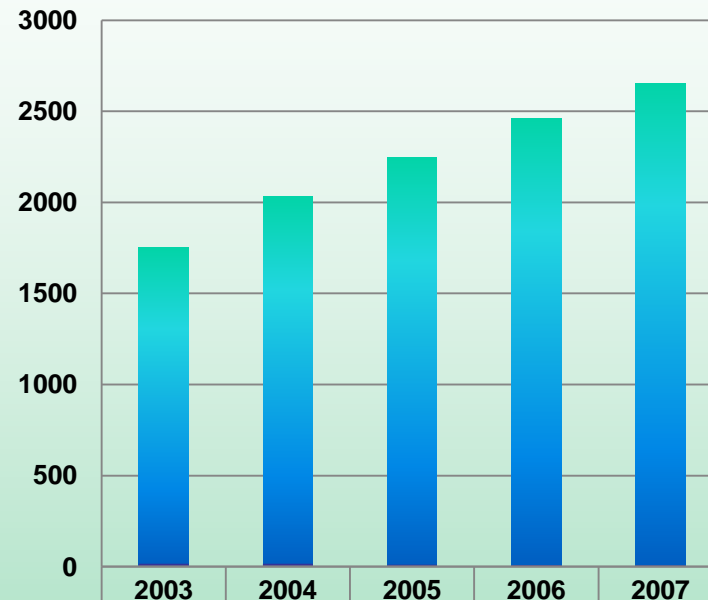


Energy Consumption

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%

Energy Consumption - China

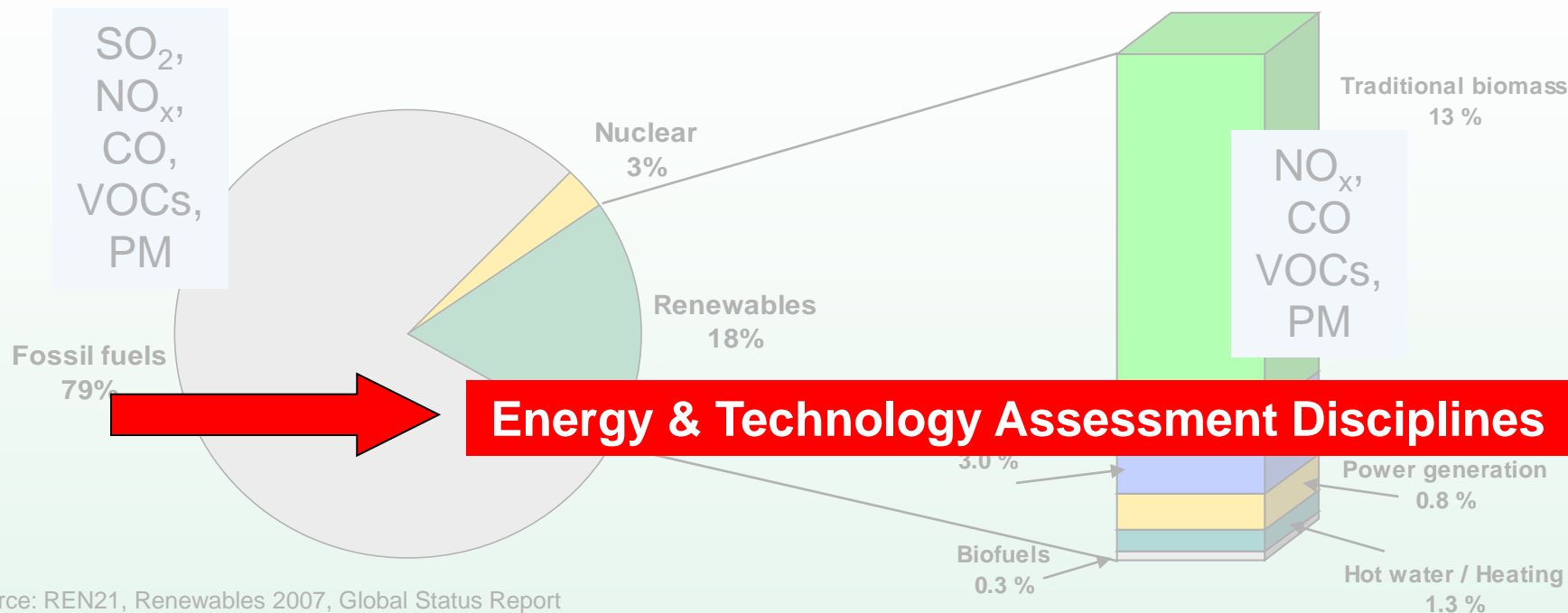


	2003	2004	2005	2006	2007
Total Energy Consumption [1 Mill. Tons CE]	1749.9	2032.227	2246.82	2462.7	2654.8
Growth Rates [%]	15.3	16.1	10.6	9.6	7.8

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

Source: China Statistical Abstract 2009

Energy Consumption



Source: REN21, Renewables 2007, Global Status Report

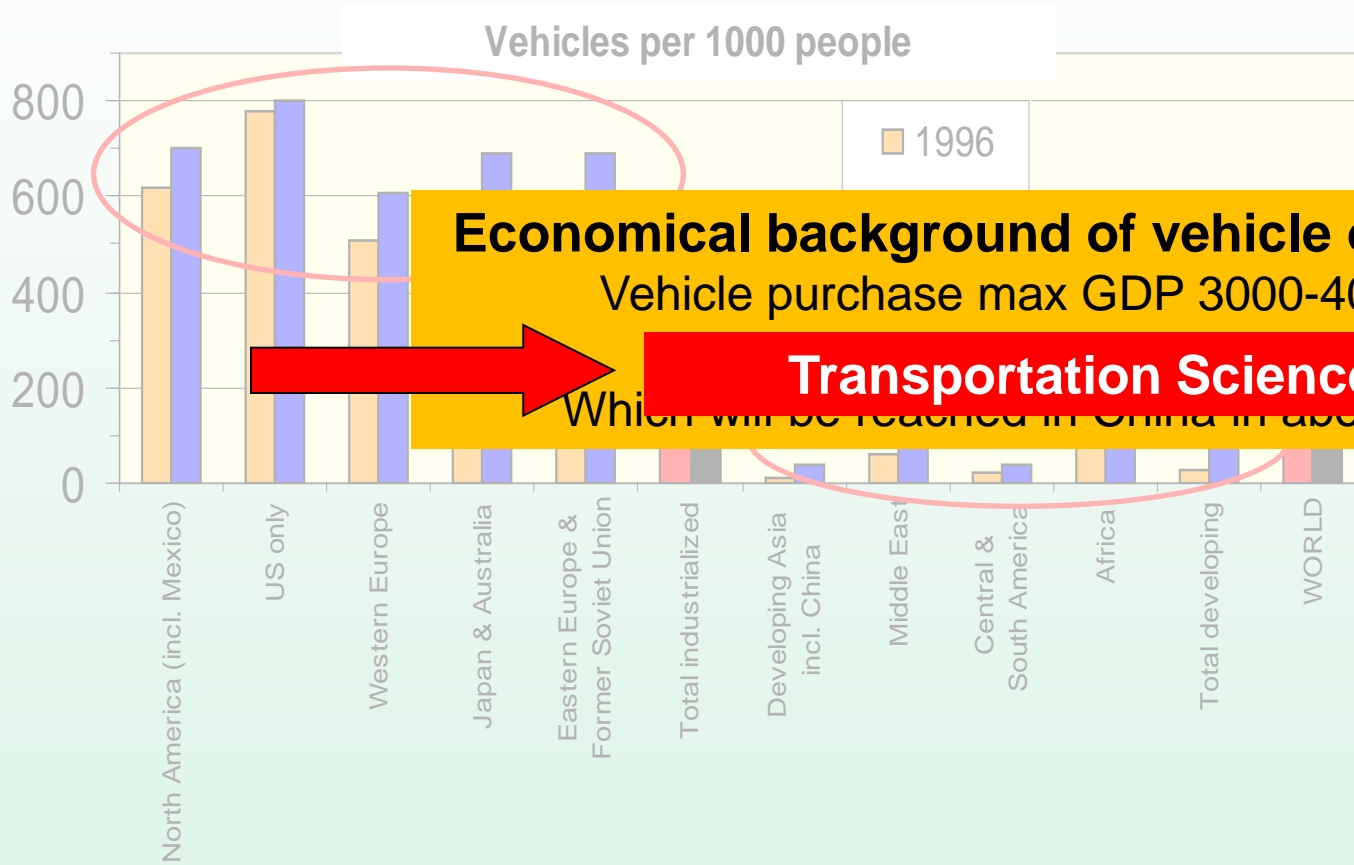


Problems and Risks

- Land use
- Energy
- Mobility



Traffic



Economical background of vehicle ownership

Vehicle purchase max GDP 3000-4000 \$

Transportation Sciences

Which will be reached in China in about 20 y

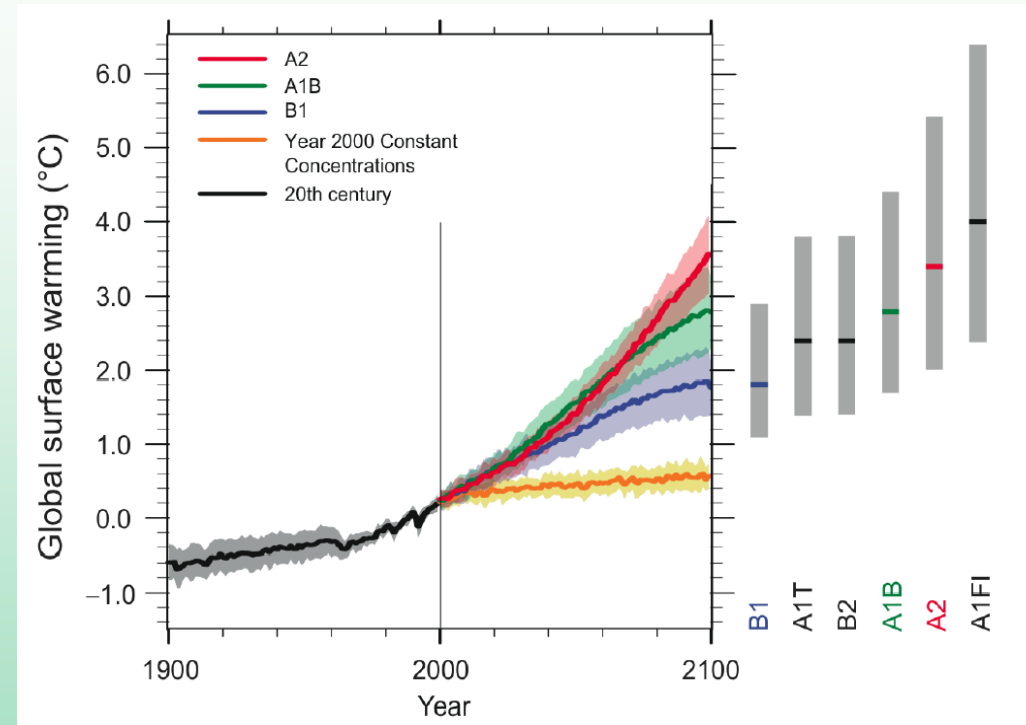


Traffic Volume in
1996 and 2020

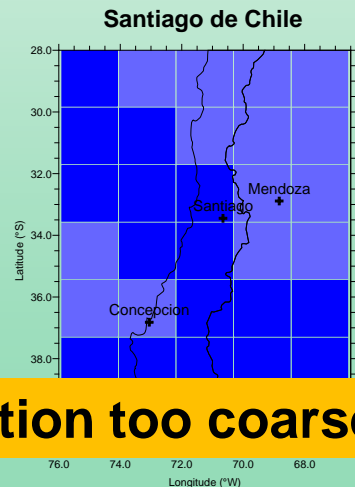
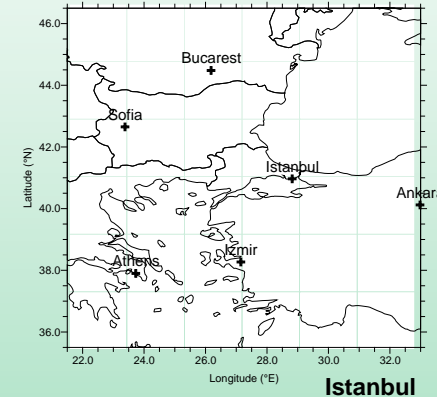
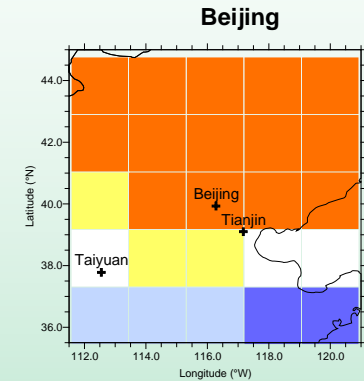
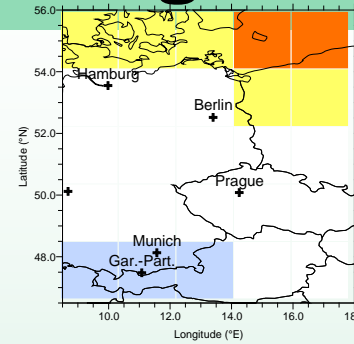
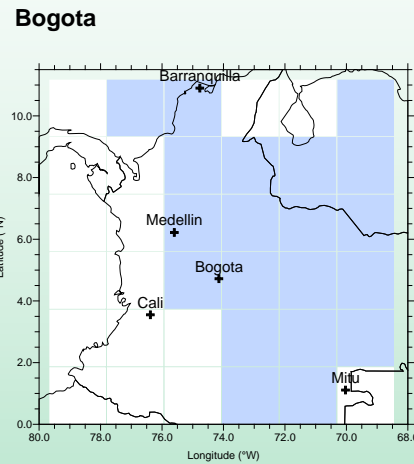
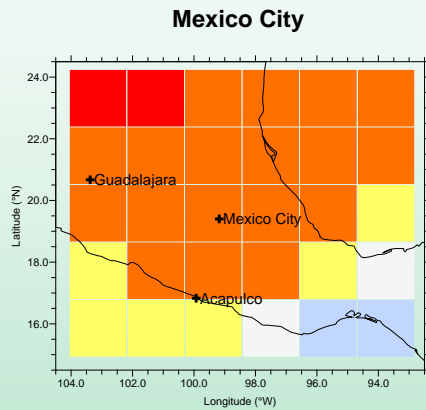
Source: US Dept.of Energy, 2000

Problems and Risks

- Land use
- Energy
- Mobility
- Climate Change

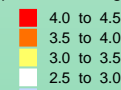


Climate Change



ECHAM5 - A1B scenario
Future (2071-2100) - Present (2001-2030)

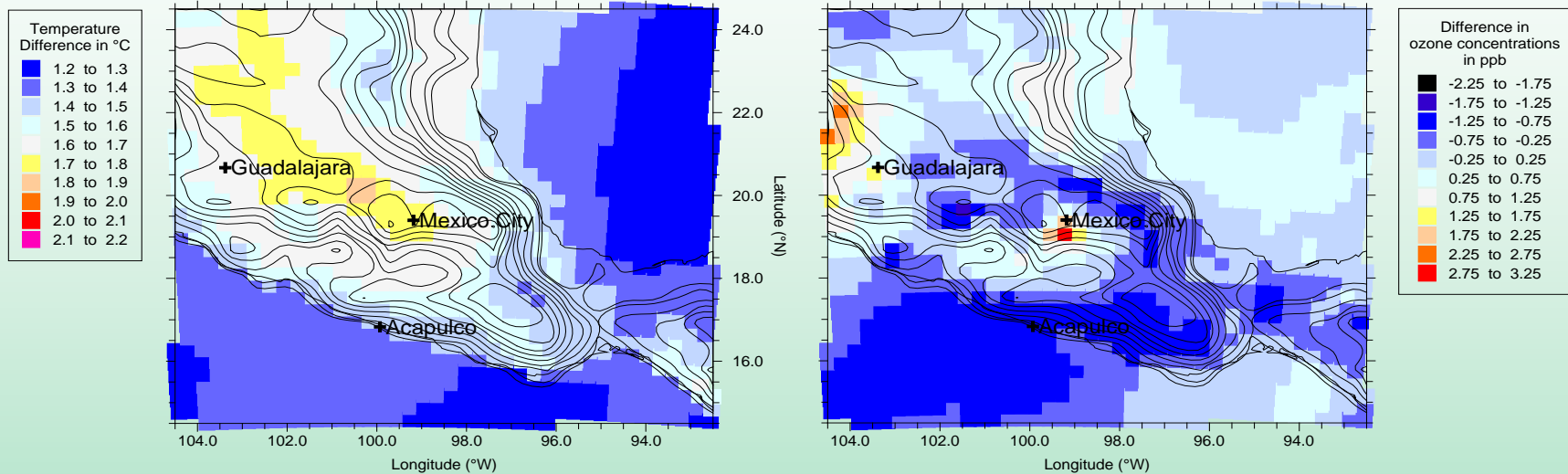
Temperature Change in °C



Climate Change
Impact on Urban
Agglomerations

Resolution too coarse for regional impact analysis !

Climate Change Impact



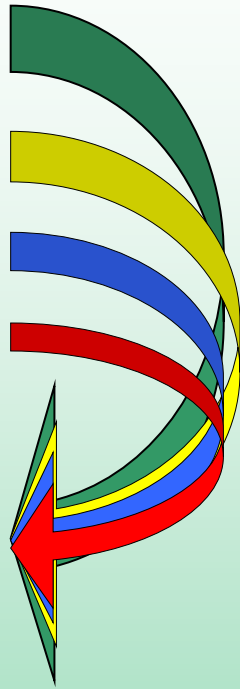
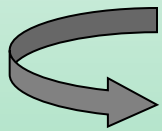
High resolution climate-chemistry simulations
- Mexico -

Source: Working Group "Air Quality"
by R. Forkel (IMK-IFU)

Problems and Risks

- Land use
- Energy
- Mobility
- Climate Change

- Air Quality
- Health Impact



integrated approach

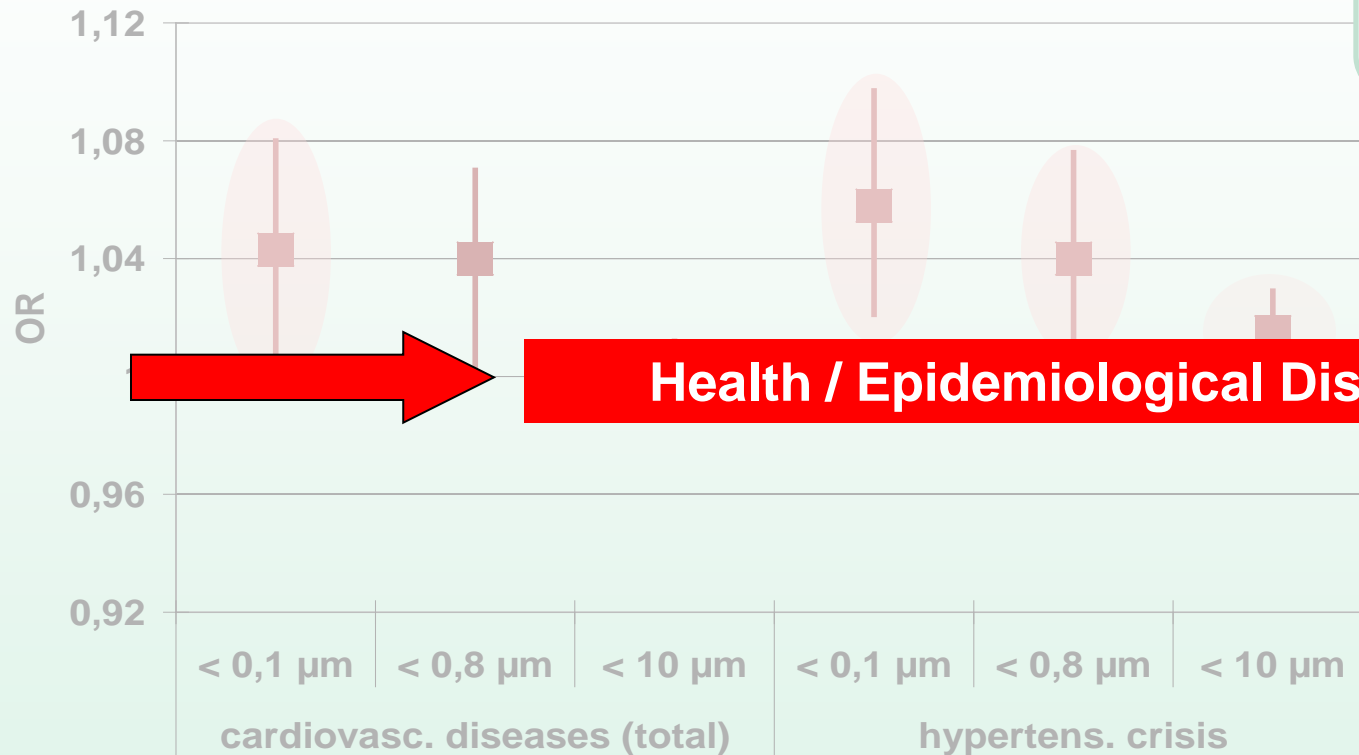


Santiago de Chile



Health Effects

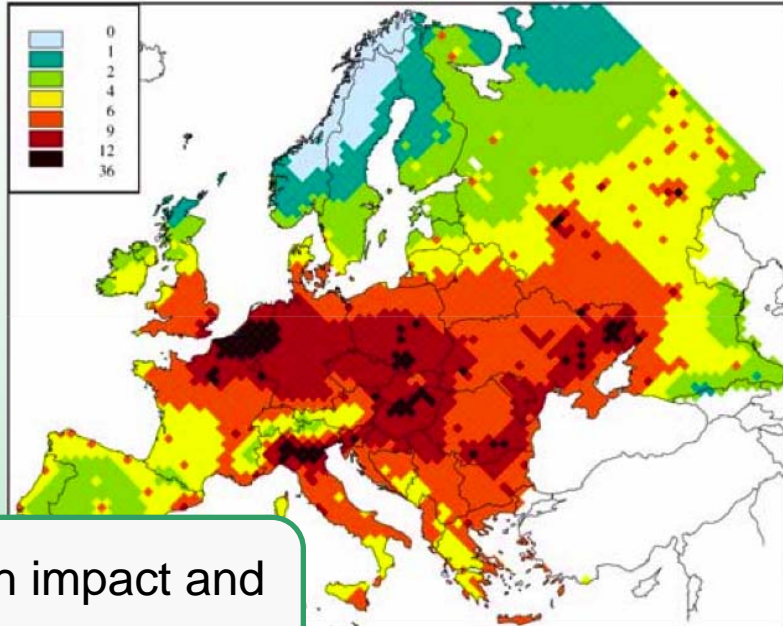
Size dependent health effects of airborne particles



Odeh SF, PhD Thesis 2006
Franck U, Odeh SF, Wiedensohler A,
Wehner B, Herbarth O et al. 2009 subm.

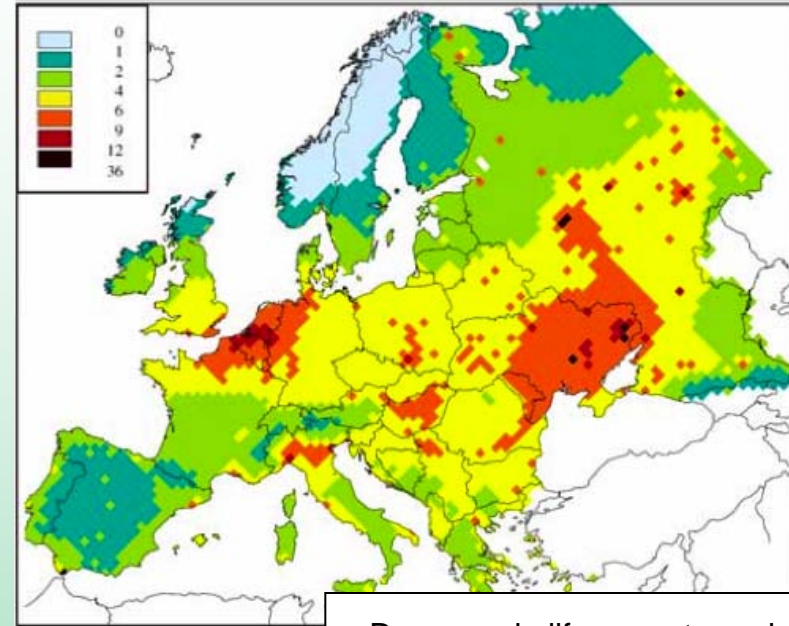
Health Facts

2000



Health impact and
air pollution

2020



Decrease in life expectancy in months
due to anthropogenic 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

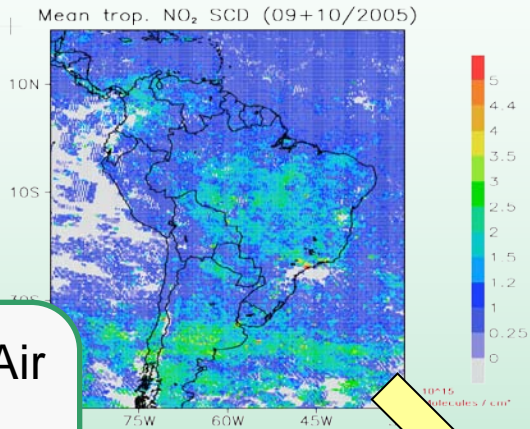
Source: CAFÉ (Clean Air for Europe), 2005
by support of Alexandra Schneider (HMGU)

Research Questions

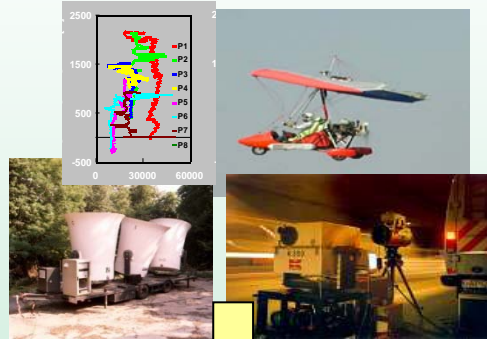
- How can we overcome the complexity of the interaction between different disciplines?
- Do we understand the complex links between emissions, air quality and health impact?
- How can act with the different scales?
- How can separate information platforms be linked to the development of an integrated approach to air quality assessment in mega cities?
- Which relationship exists between specific air pollutants like PM₁₀ or NO₂ and the appearance of environment-related diseases?
- How to develop scenarios that they are in line with the climate change scenarios?

Methodology

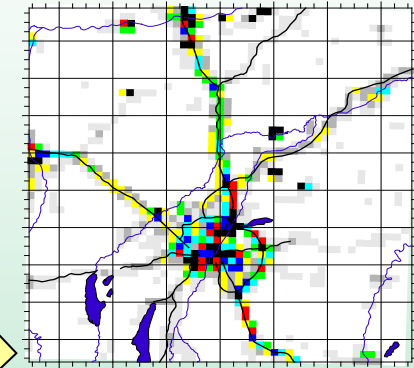
Satellite data



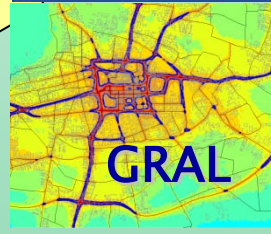
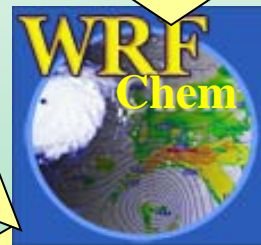
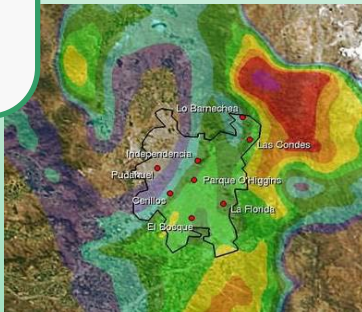
Measurement data



Emission data



Integrated Air Quality Assessment Studies



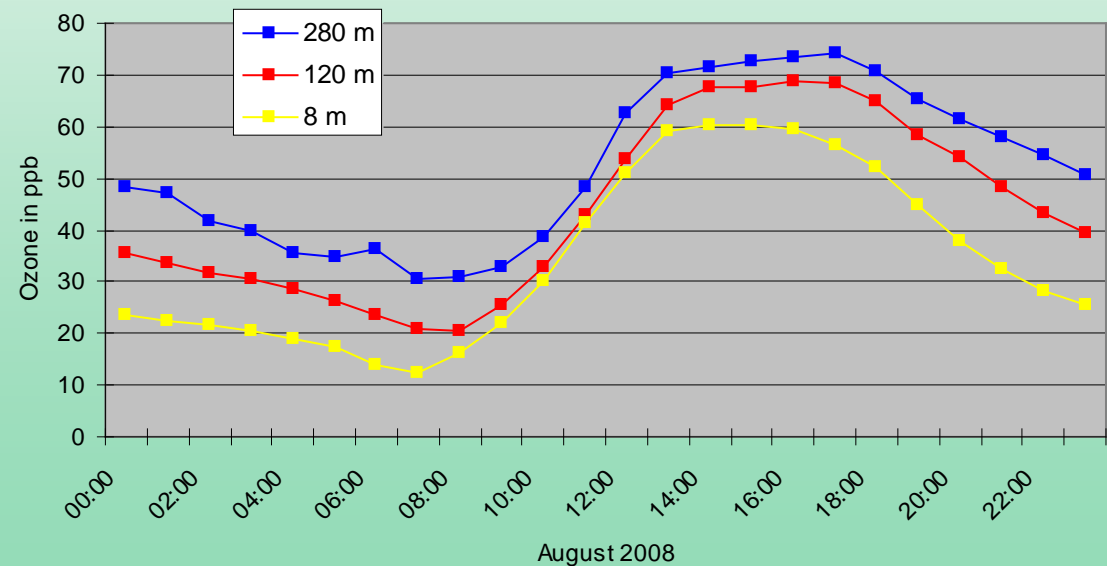
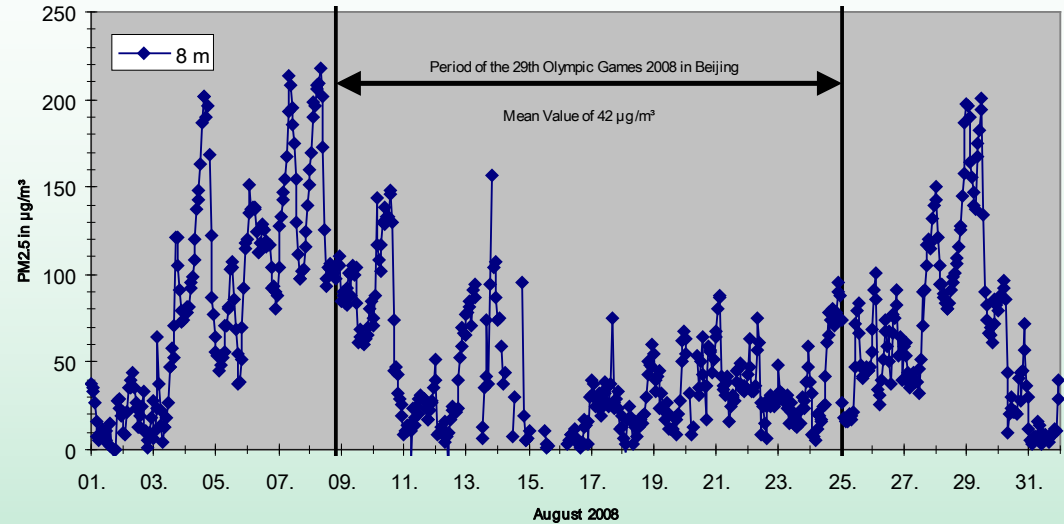
Air quality

science based decision support

Measures

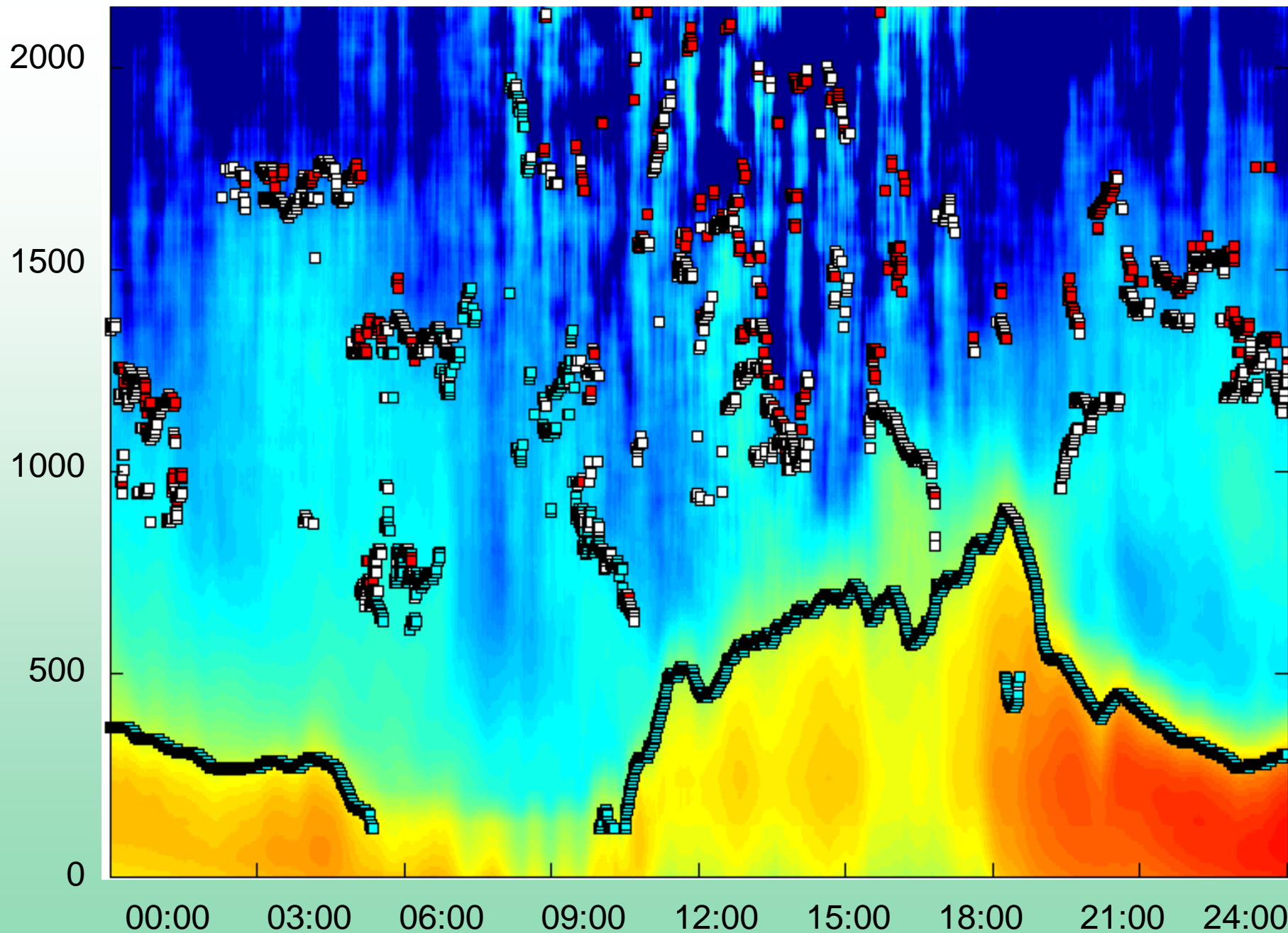
Vertical Measurements

Vertical measurements - Beijing -



Source: X. Jinyuan (CAS), China

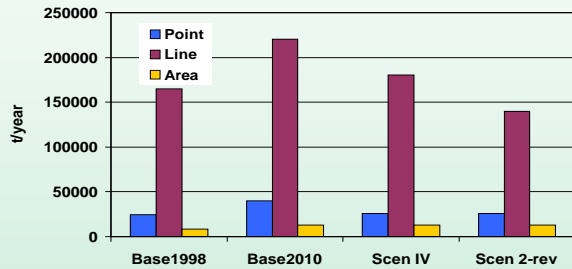
Height above around [m] 地面上高度 [米]



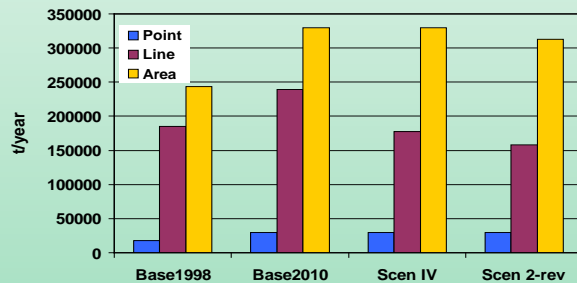
Adaptation Strategies

e.g. Mexico City

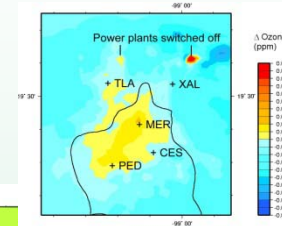
NOx emission



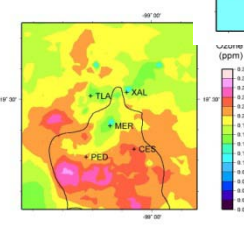
VOC emission



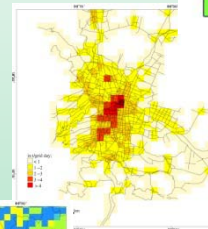
Basic information on present emissions and emissions of reduction measures



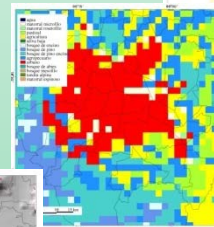
O₃-difference in 2010



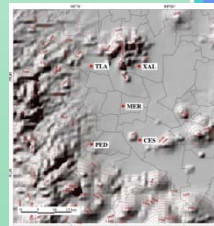
O₃-concentrations in 2010



NOx Emissions



Land use



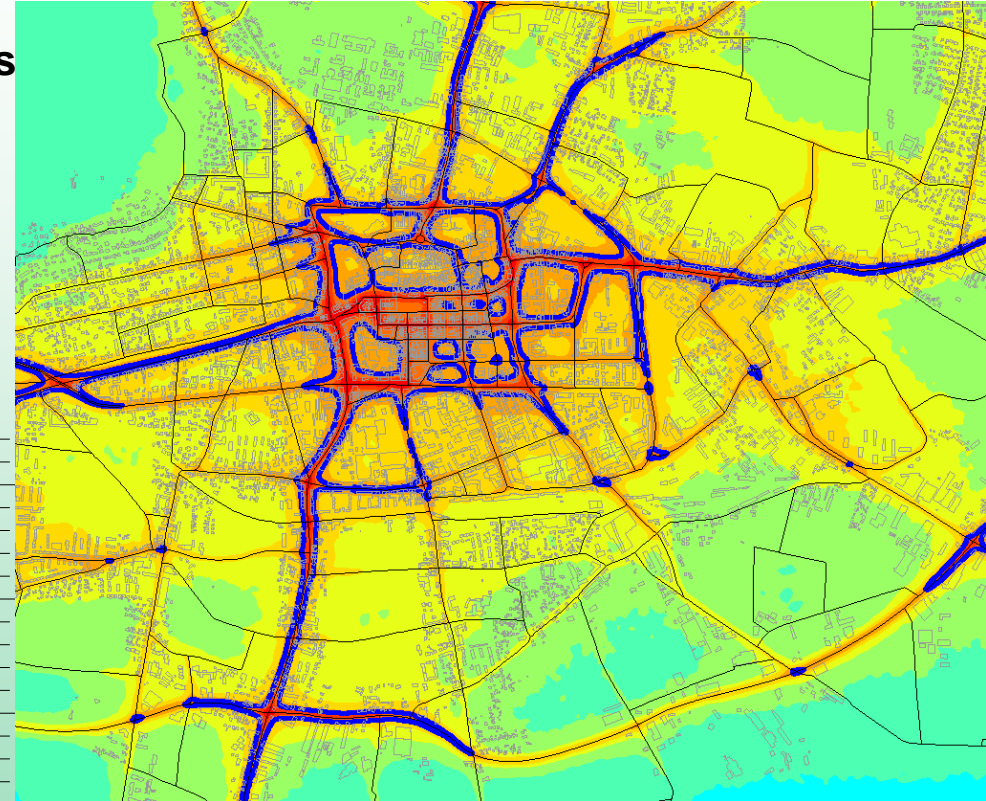
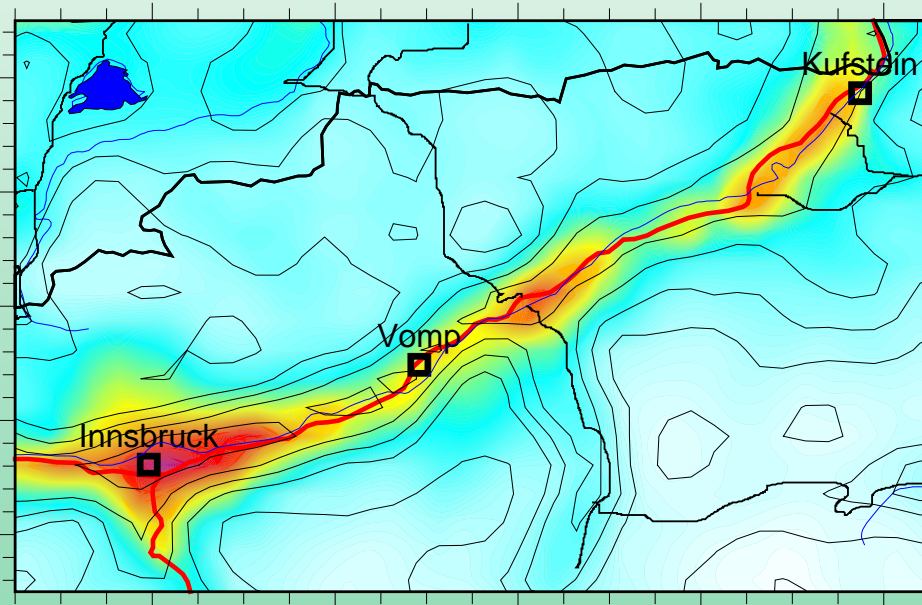
Topography

Source: Working Group "Air Quality" by R. Forkel (IMK-IFU)

Coupling of Scales

Threshold
exceedances

Meso-scale modeling
e.g. NO₂ with MCCM

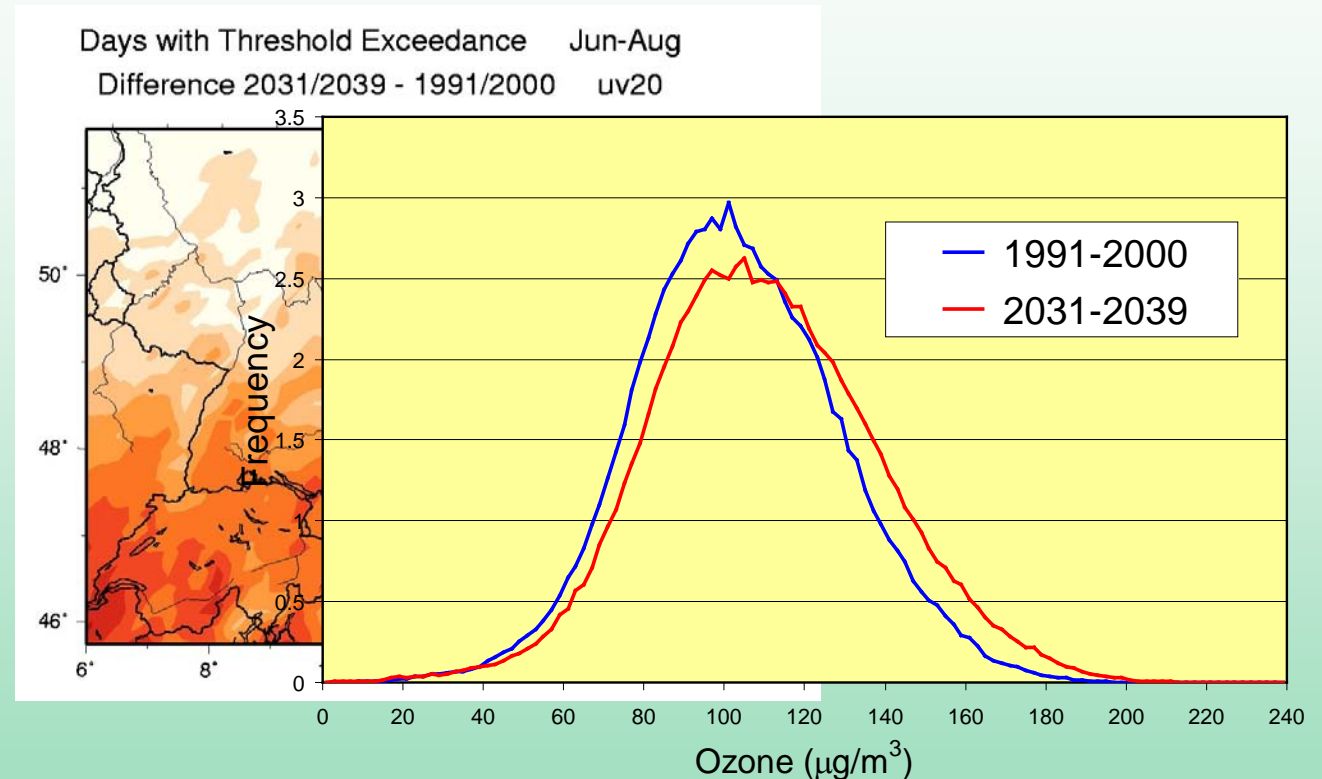


Source: EU-LIFE Project
Klagenfurt Graz Bozen

KAPA GS

Micro-scale modelling
e.g. NO₂ with GRAL

Climate Change Impact

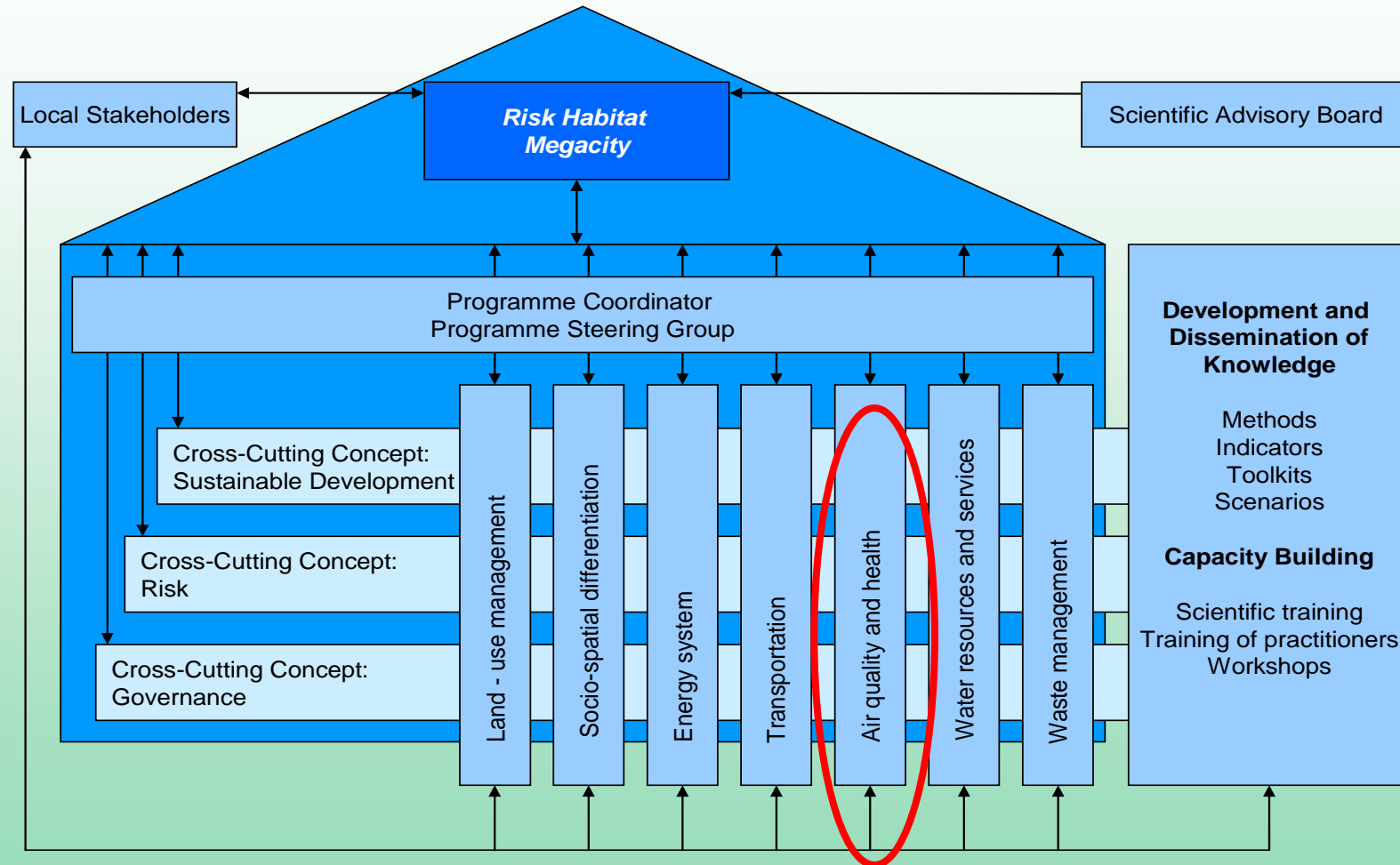


Threshold exceedances in the future
Distribution of daily O_3 maximum

Setup: 60-20 km grid
2x10 years period
Southern Germany

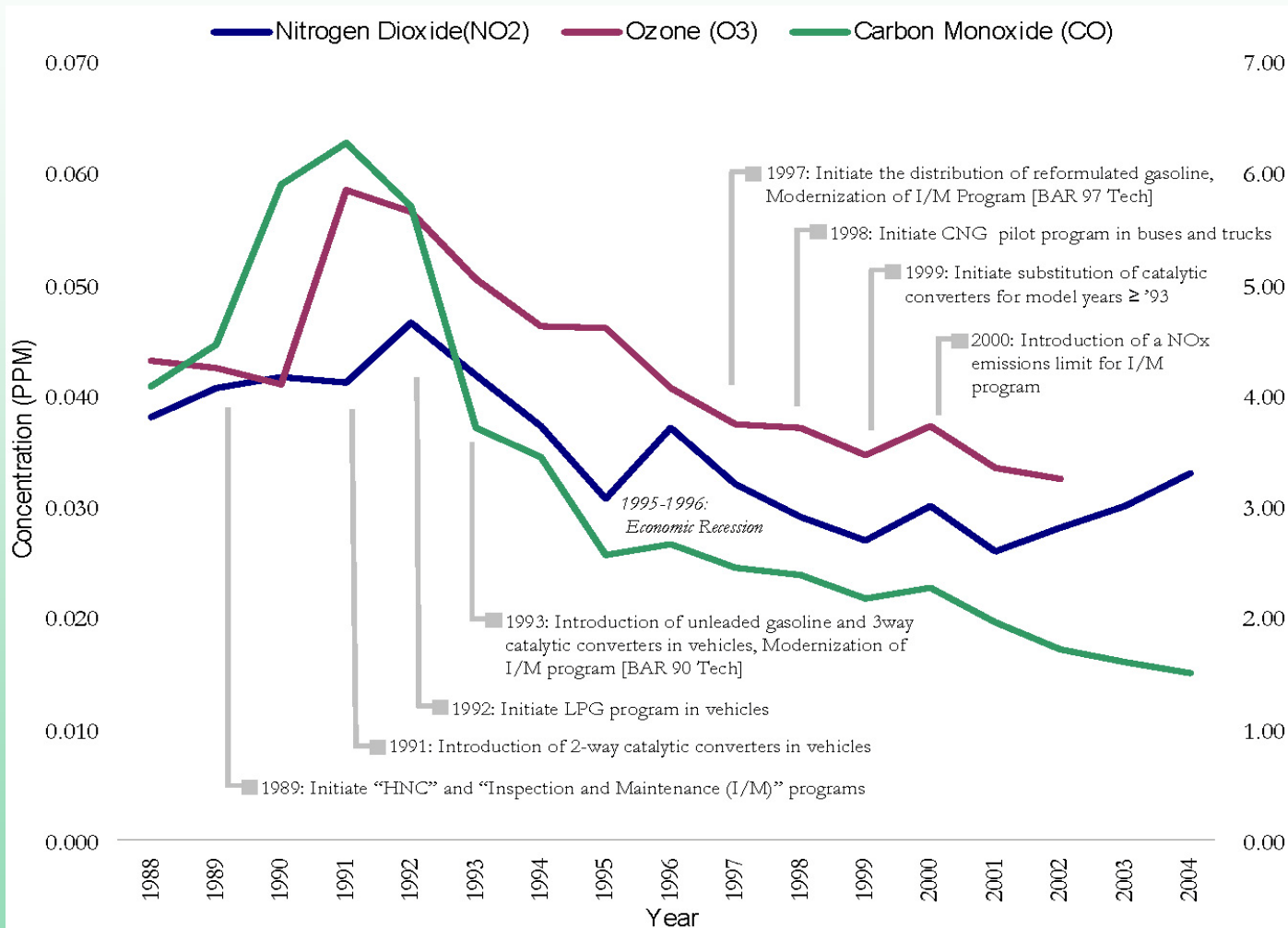
Source: R. Forkel (IMK-IFU)

Research Project



Risk Habitat Megacity
¿sostenibilidad en riesgo?

Governance & Sustainability



Air Quality management policies, emission control programs and pollutant trends in Mexico City

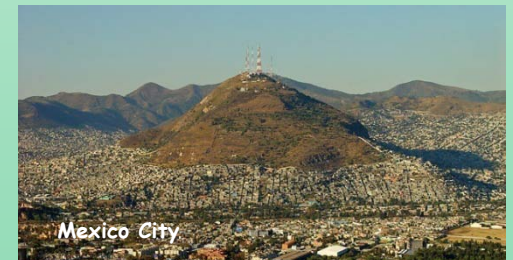
Source: APERC (2007): Urban Transport Energy Use in the APEC Regions

Conclusions

- Air quality issues need an holistic and interdisciplinary approach
- In order to understand the complex system of a mega city, further process studies have to be done in each discipline
- Link between the fields of land-use, energy, transportation, air quality, climate change and health demonstrates the interaction and tackles central problems in a mega city
- Air quality and health impact assessment studies are essential prerequisites for mitigation and adaptation strategies and for reducing e.g.
 - environmental risks (air pollution, congestion, waste, ...)
 - social risks (spatial segregation, health problems, ...)
 - costs (healthcare system, transportation, production, ...)

Co-operations

- **Memorandum of Understanding (MoU)** between IMK-IFU and the **Universidad Nacional Autonoma de Mexico (UNAM)** about a cooperation in the fields of research and education (e.g. *Air Quality, Climate Change*)
- Establishing of the **International Competence Center for Sustainable Urban Development (ISUD)** in Santiago de Chile (“*capacity building*”; “*multidisciplinary research on Megacities*”; “*applying knowledge*”) between FZK and **Universidad de Chile** in Santiago
- **Contract of Cooperation** between the **Institute of Atmospheric Physics (IAP)** of the **Chinese Academy of Sciences (CAS)** and IMK-IFU about “*Monitoring and Modelling of Air Quality at the Megacity, Beijing*”



Thank you very much for your attention

Cooperation Partner

Yuesi Wang, Hong Liao, Xin Jinyuan
Jose Agustín García, Gerardo Ruiz
Rainer Schmitz, Ricardo Muñoz
Michael Hagen
Frank Baier
Ulrich Franck
Annette Peters, Josef Cyrus

*Chinese Academy of Sciences (CAS), Peking
Universidad Nacional Autonoma de Mexico (UNAM)
Universidad de Chile , Santiago de Chile (UdC)
Fondo Nacional de Salud (FONASA)
Deutsches Luft- und Raumfahrtzentrum (DLR)
Helmholtz Zentrum für Umweltforschung (UFZ)
Helmholtz Zentrum München (HMGU)*