Air Quality: A challenge for interdisciplinary research

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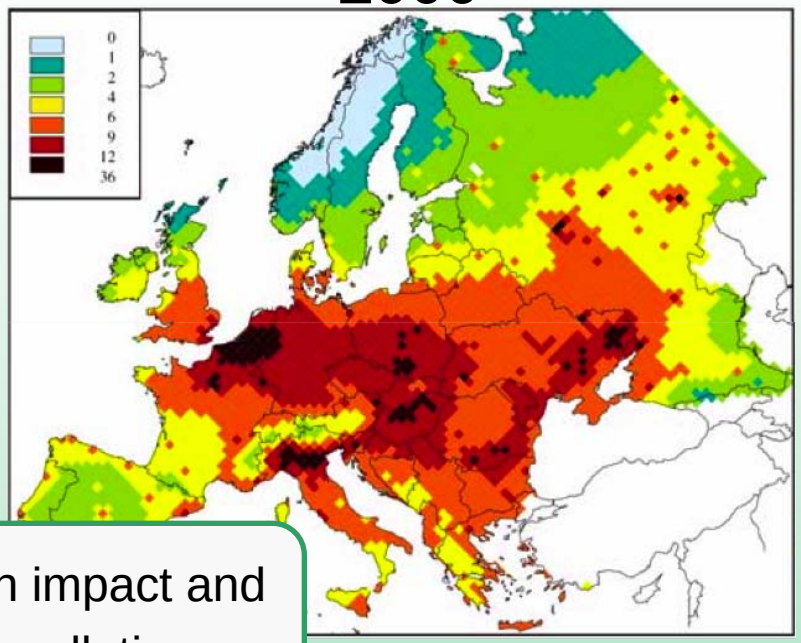
Research Focus

Air Quality in Metropolitan Areas and Sensitive Regions

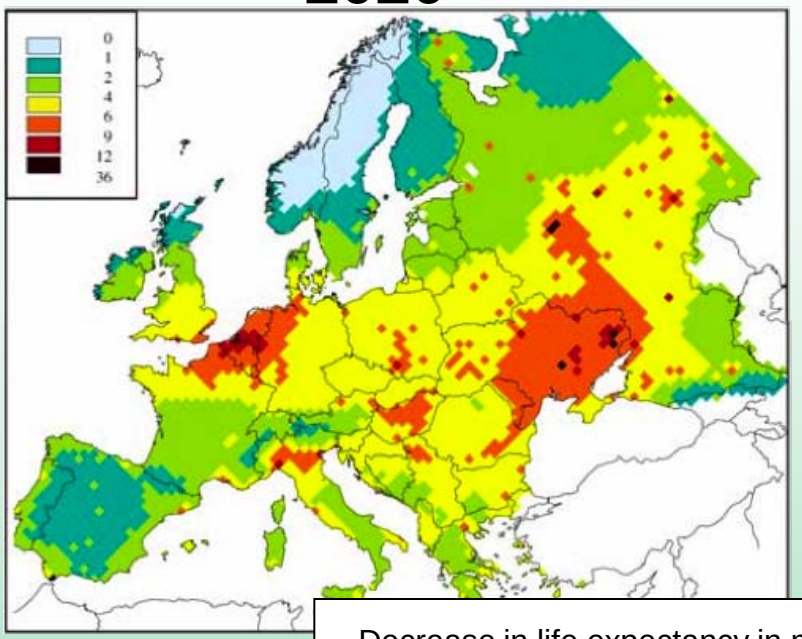
- Interactions between urban/suburban/rural regions and their feedback mechanism to the air quality
- Impact of regional climate change on air quality
- Developing and validation of innovative measuring techniques for the assessment of the air quality (e.g. urban agglomerations – close cooperation with 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

Health Facts

2000



2020



Health impact and air pollution

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)

Mortality rates on PM_{10} increase

Region	Percentage change	Reference
Asia	0.49% (0.23-0.76)	HEI, 2004
Europe	0.60% (0.40-0.80)	Katsouyanni, 2001
Latin America	0.61% (0.16-1.07)	PAHO, 2005*
United States	0.21% (0.09-0.33)	Dominici, 2003
Worldwide	0.65% (0.51-0.76)	Stieb, 2002

Source: PAN American Health Organization, 2005

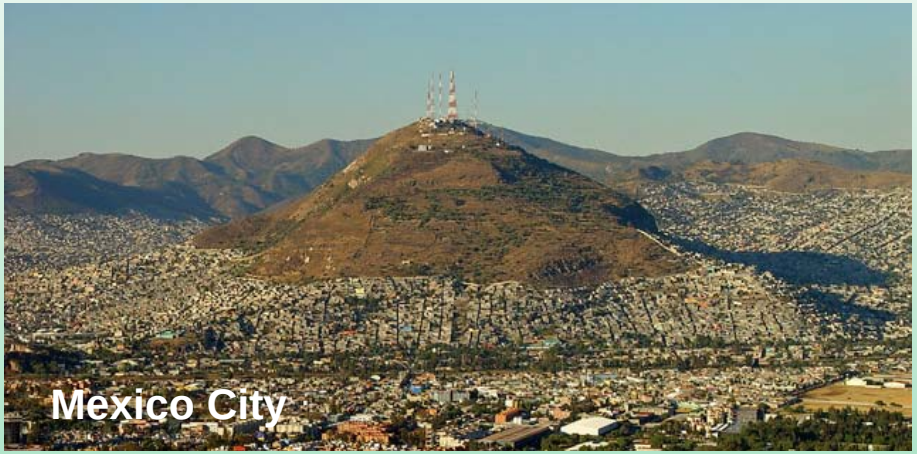
* Based on studies in Mexico City, São Paulo, Santiago de Chile

What to do now?

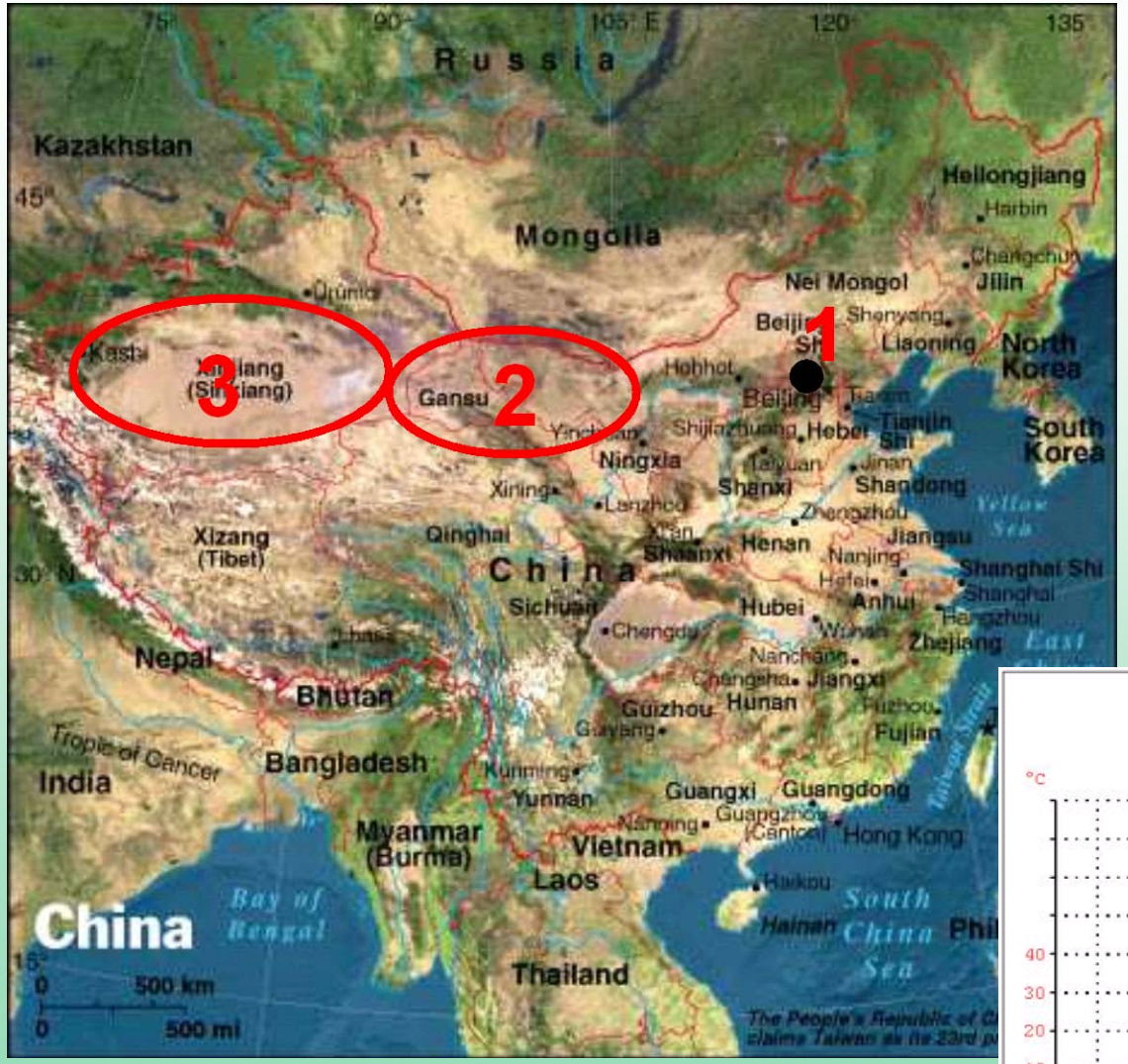
- The complex chemical interactions of emissions – transmission - air pollution – deposition / exposure needs detailed investigations on the causal chain
- Only interdisciplinary approaches allow holistic analysis
- But which disciplines are in relation to the air pollution, where we can turn the screw to get a cleaner and healthier air ?
- …

Impact on Air Quality

- Land use



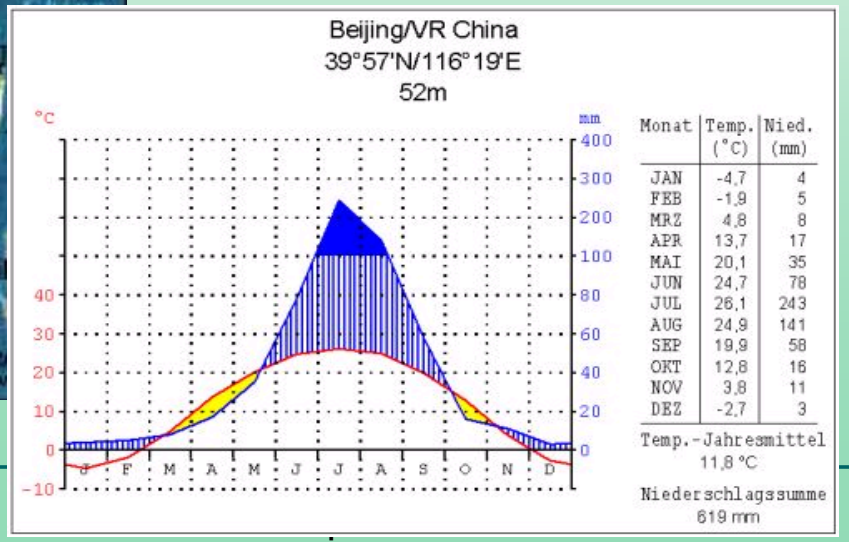
Natural land use change



1: Beijing

2: Desert Gobi

3: Desert Takla Makan

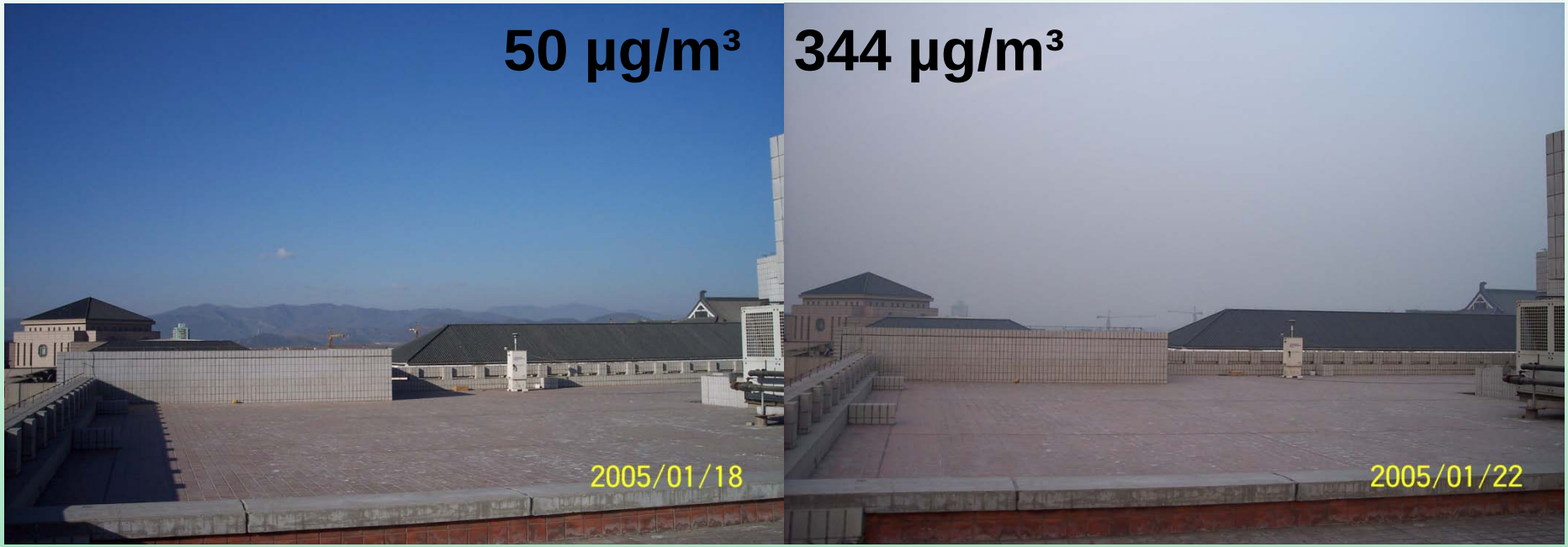


Source: Stefan Norra, University Karlsruhe (IMG)

Beijing

18.04.2006

Photos by Stefan Norra

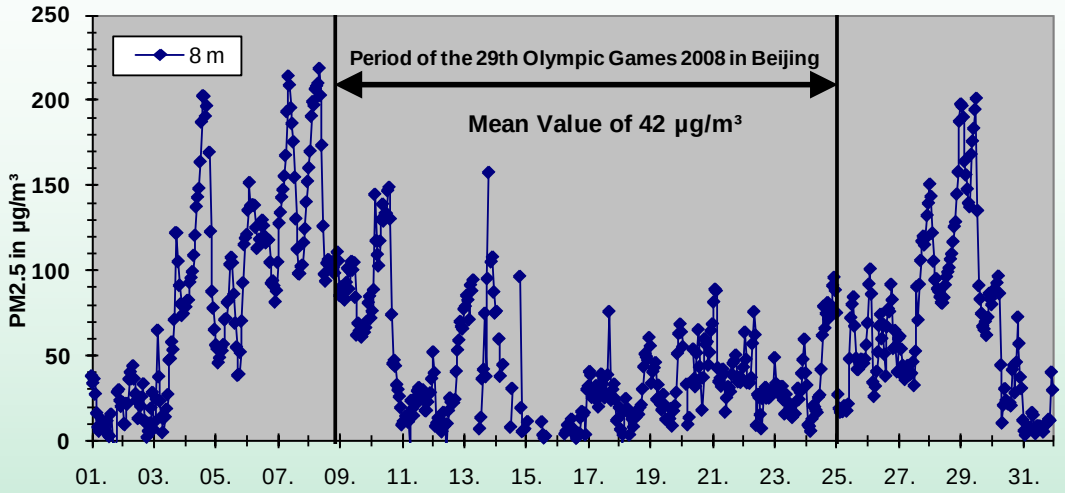


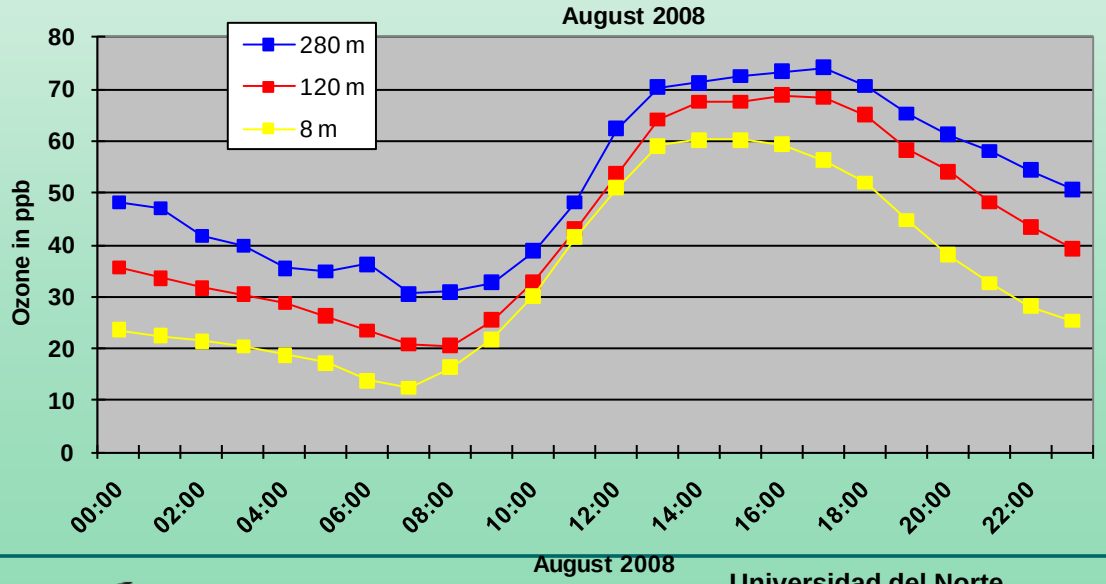
Source: Matthias Tesche, IfT

Vertical Measurements

Vertical measurements
- Beijing -

Source: X. Jinyuan (CAS), China



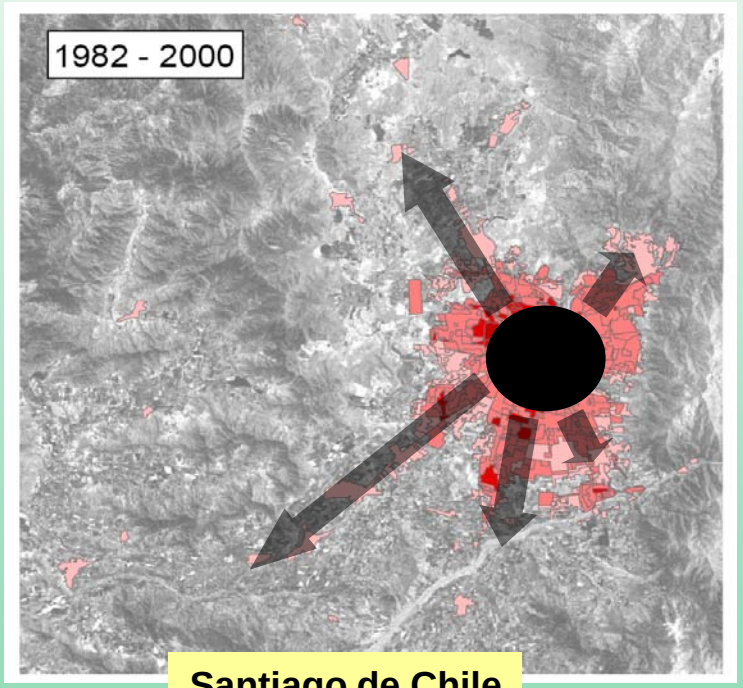


Land Use Change

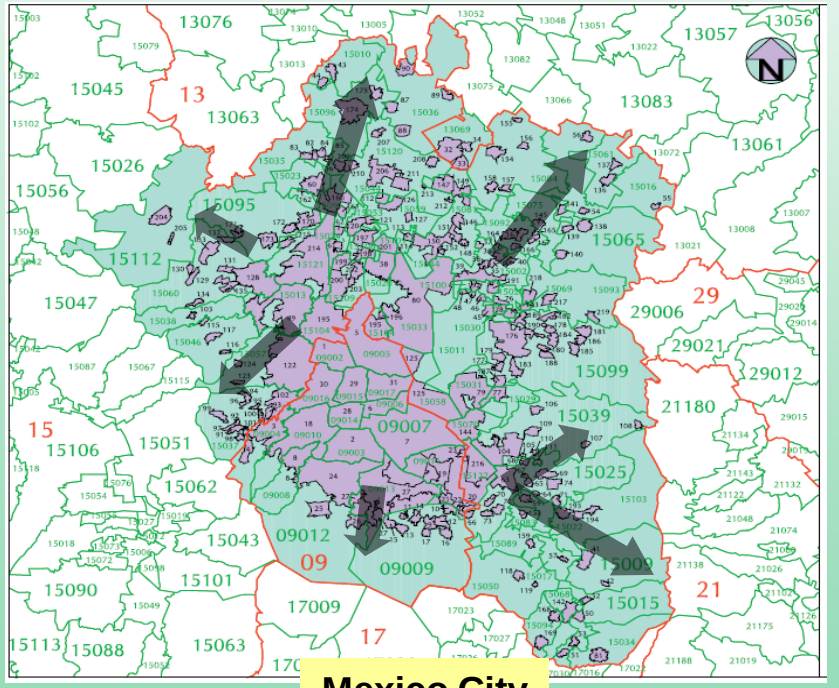
	Santiago de Chile 2002	Mexico City 2005
Population	6.061.000	19.410.000
Urbanized area (km²)	641	1800
Population density (p / km²)	9.500	10.800
Population growth (% / y)	~1,32	~1,28

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

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



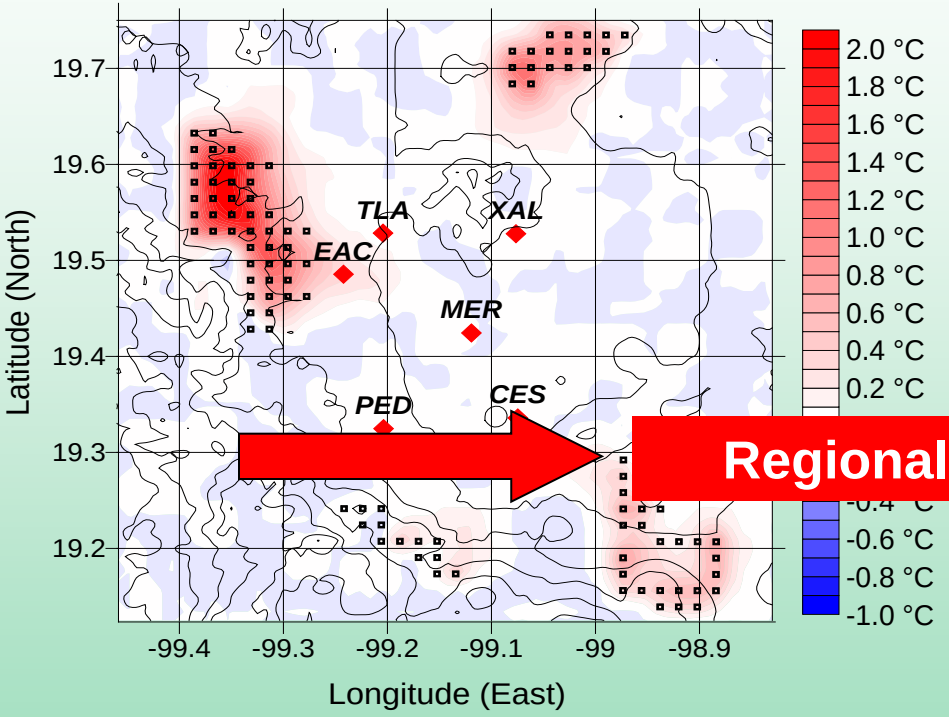
Santiago de Chile



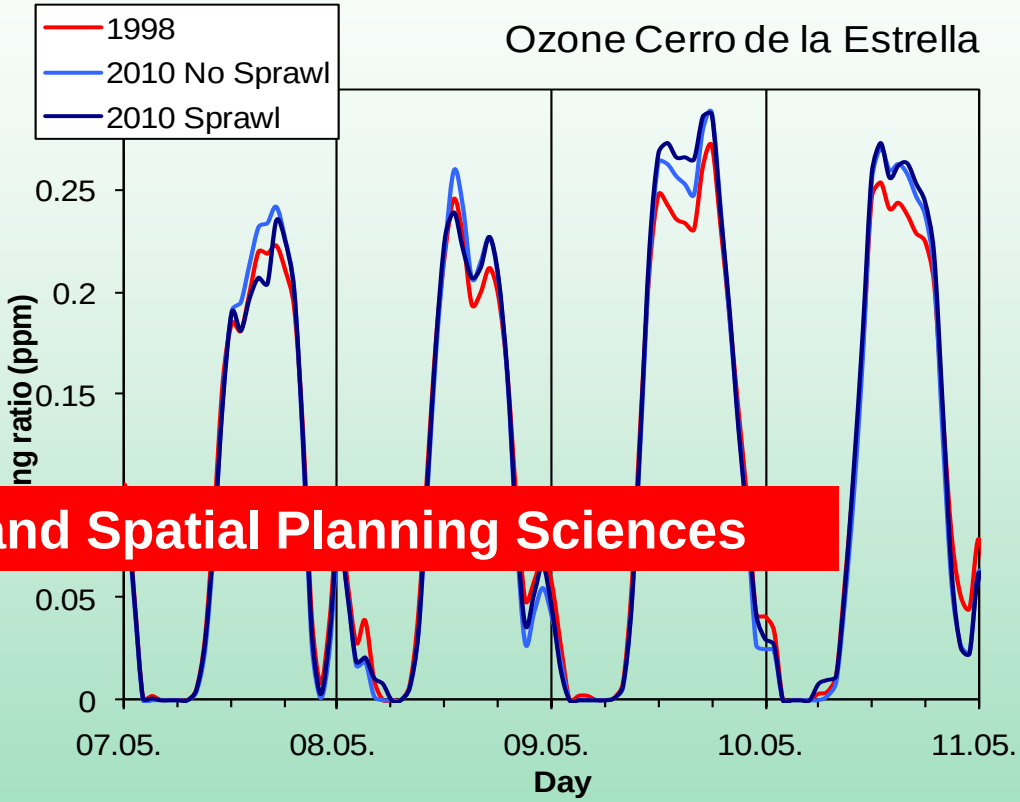
Mexico City

Peter Suppan, Institute for Meteorology and Climate Research (IMK-IFU)

Effect of land use change



Temperature difference
with and without urban sprawl

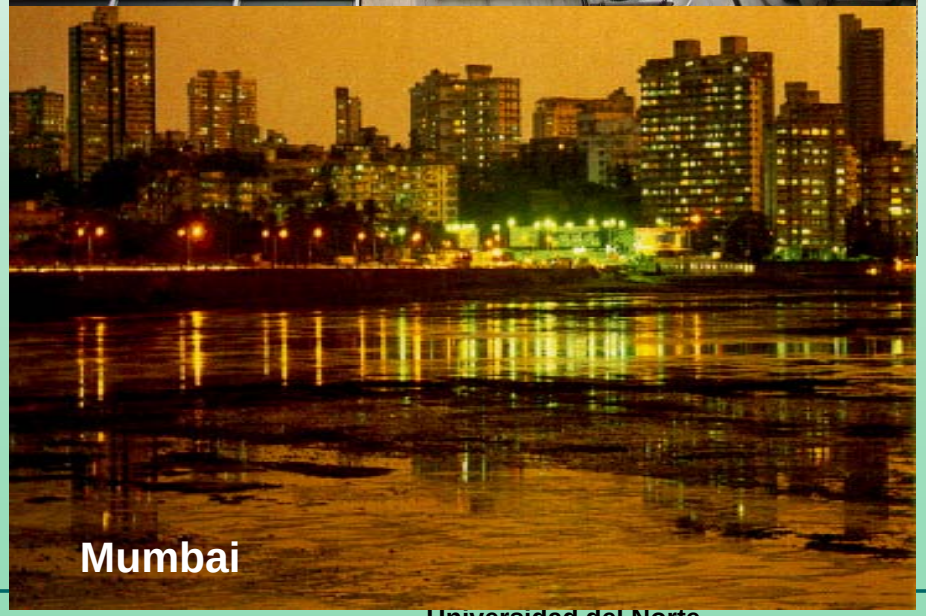


Diurnal variation of ozone concentrations
considering land use change

Regional and Spatial Planning Sciences

Impact on Air Quality

- Land use
- Energy

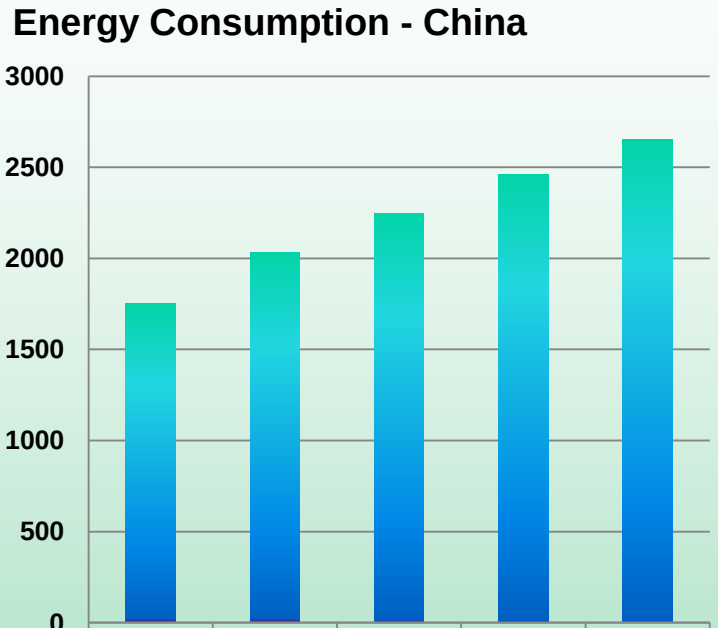


Energy Consumption

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%

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

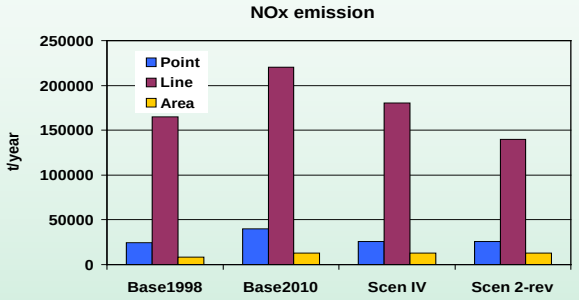


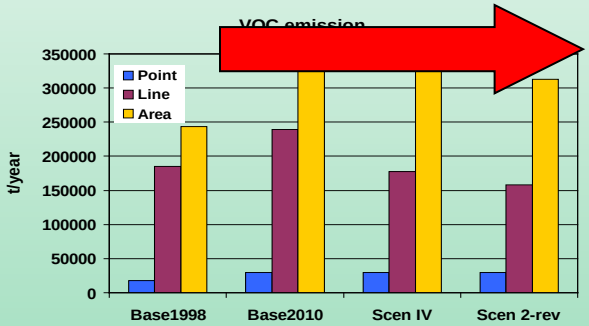
	2003	2004	2005	2006	2007
Total Energy Consumption [1 Mill. Tons CE]	1749.9	2032.227	2246.82	2462.7	2654.8
Growth Rates [%]	15.3	16.1	10.6	9.6	7.8

Source: China Statistical Abstract 2009

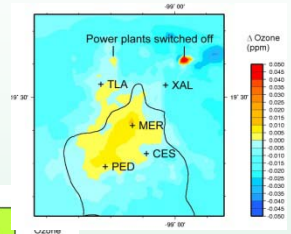
Adaptation Strategies

e.g. Mexico City

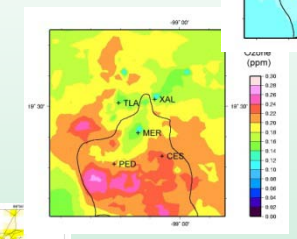




Basic information on present emissions and emissions of reduction measures



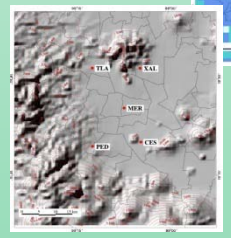
O_3-difference in 2010



O_3-concentrations

Energy & Technology Assessment Disciplines

NOx Emissions



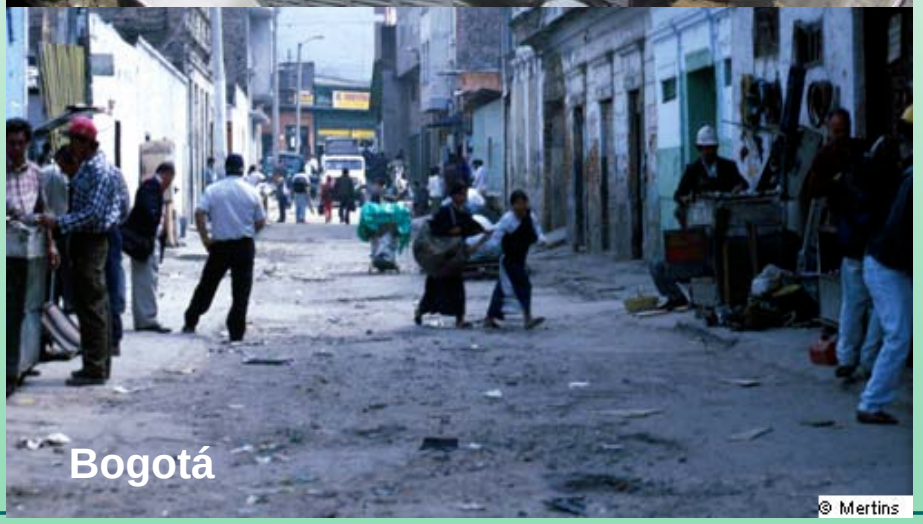
Land use

Topography

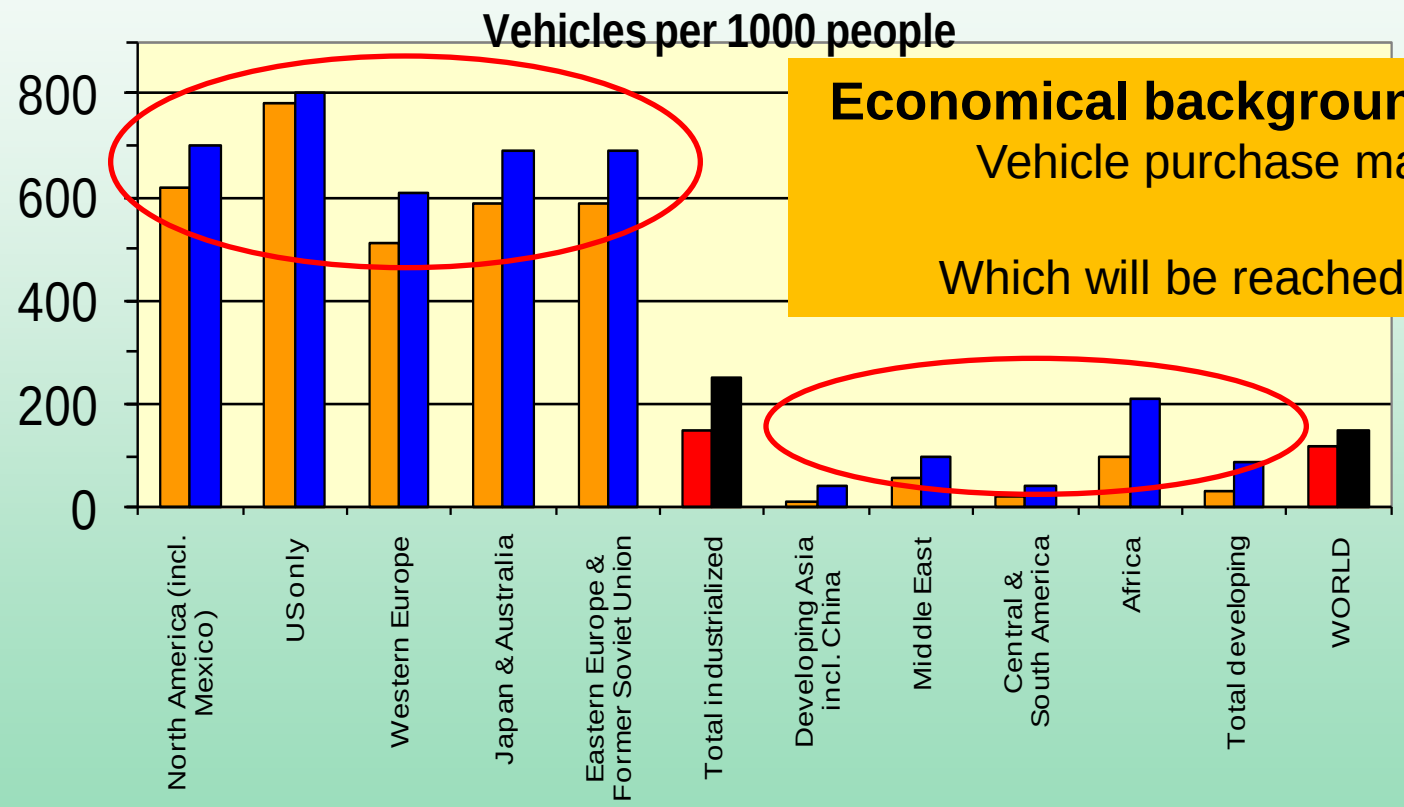
Source: Working Group “Air Quality” by R. Forkel (IMK-IFU)

Impact on Air Quality

- Land use
- Energy
- Mobility



Traffic



Economical background of vehicle ownership

Vehicle purchase max GDP 3000-4000 $

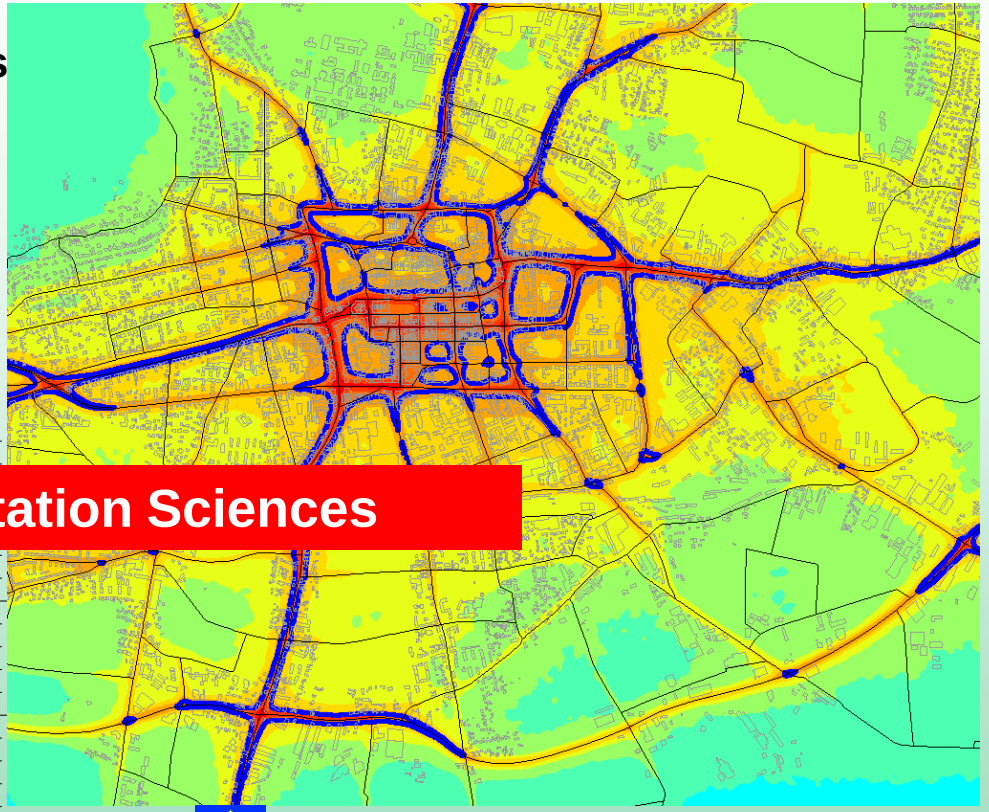
Which will be reached in China in about 20 y

Traffic Volume in 1996 and 2020

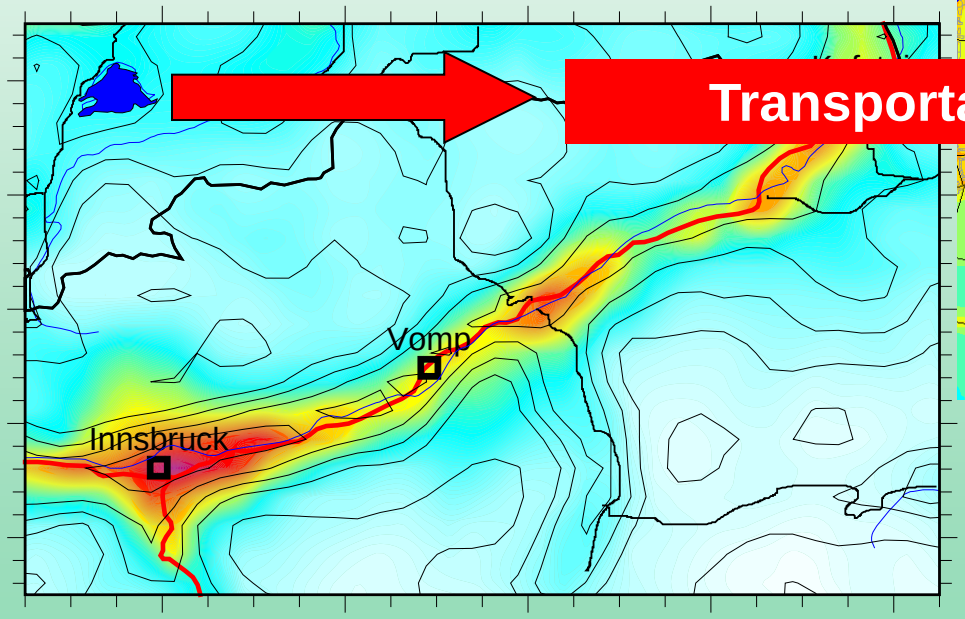
Source: US Dept.of Energy, 2000

Coupling of Scales

Threshold exceedances



Meso-scale modeling e.g. NO_2 with MCCM



Transportation Sciences

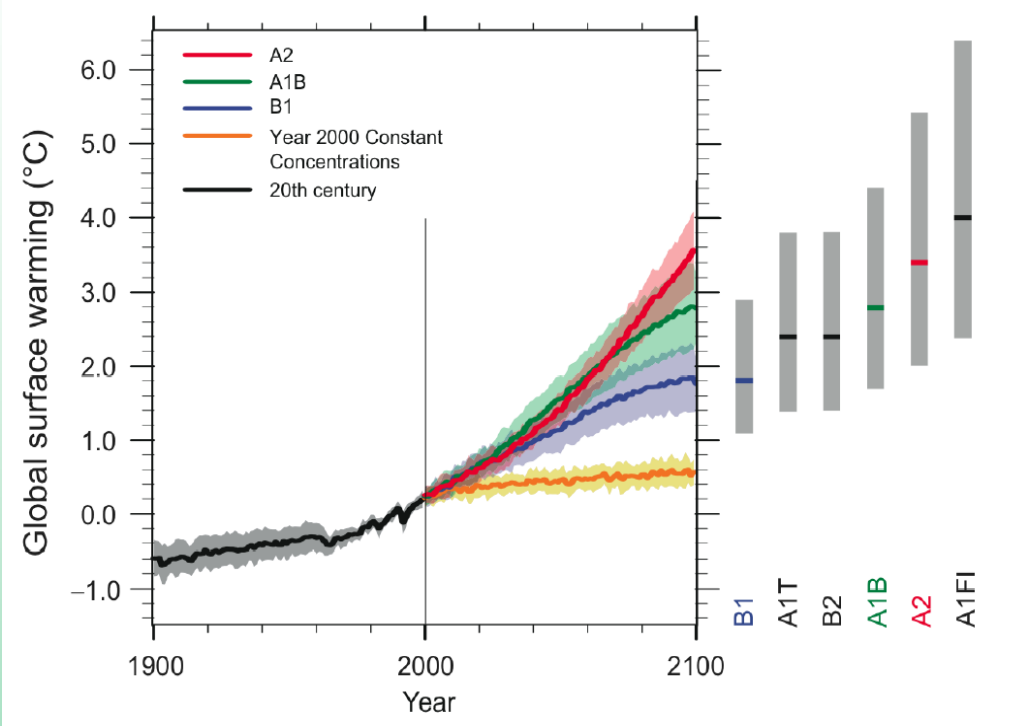
Source: EU-LIFE Project
Klagenfurt Graz Bozen

KAPA GS

Micro-scale modelling e.g. NO_2 with GRAL

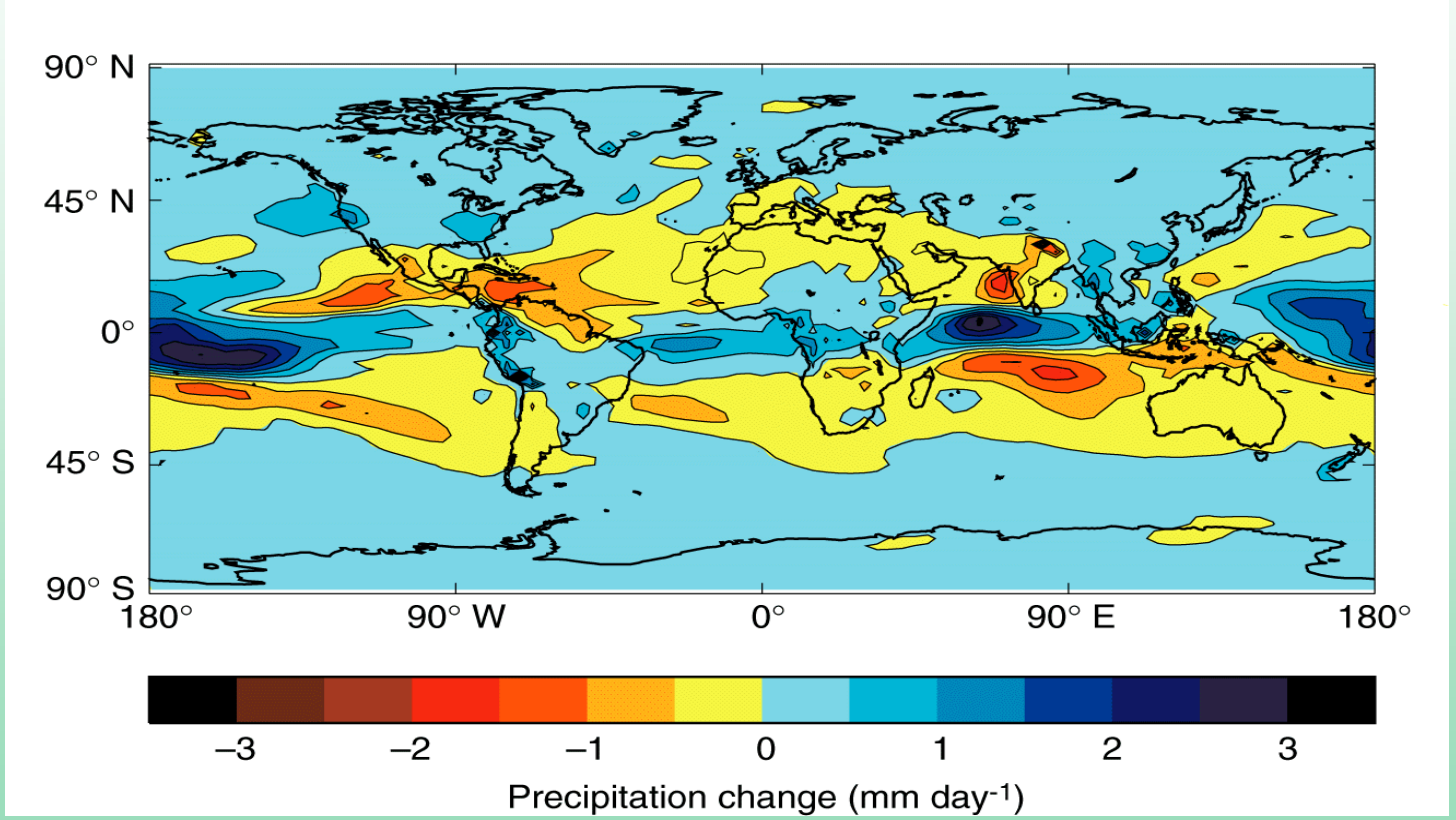
Impact on Air Quality

- Land use
- Energy
- Mobility
- Climate Change



Climate Change

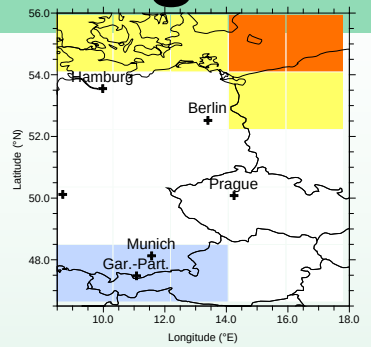
Global Climate Scenarios:
Projected Changes in Annual Precipitation for the 2050s



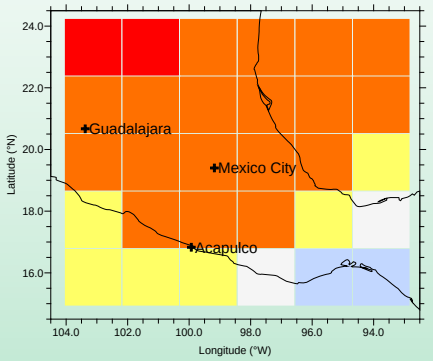
Hadley Centre for Climate Prediction and Research

Climate Change

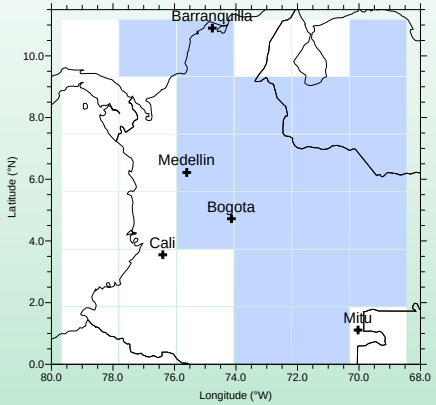
Berlin



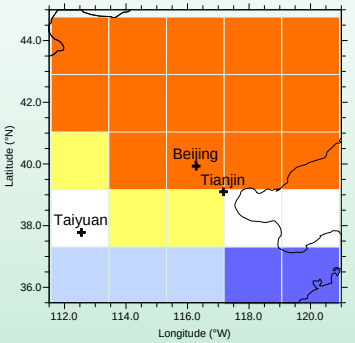
Mexico City

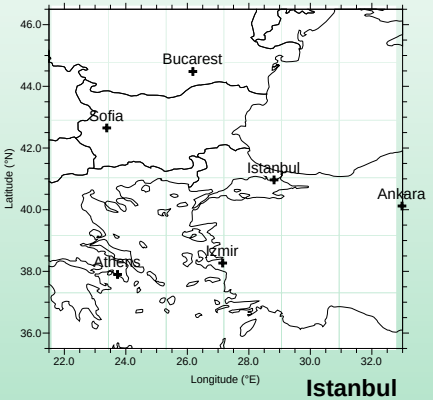


Bogota



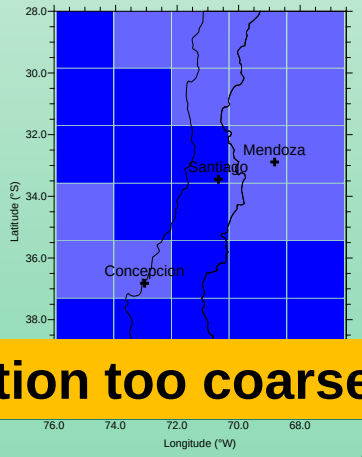
Beijing





Istanbul

Santiago de Chile



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

Temperature Change in °C

- 4.0 to 4.5
- 3.5 to 4.0
- 3.0 to 3.5
- 2.5 to 3.0

Climate Change Impact on Urban Agglomerations

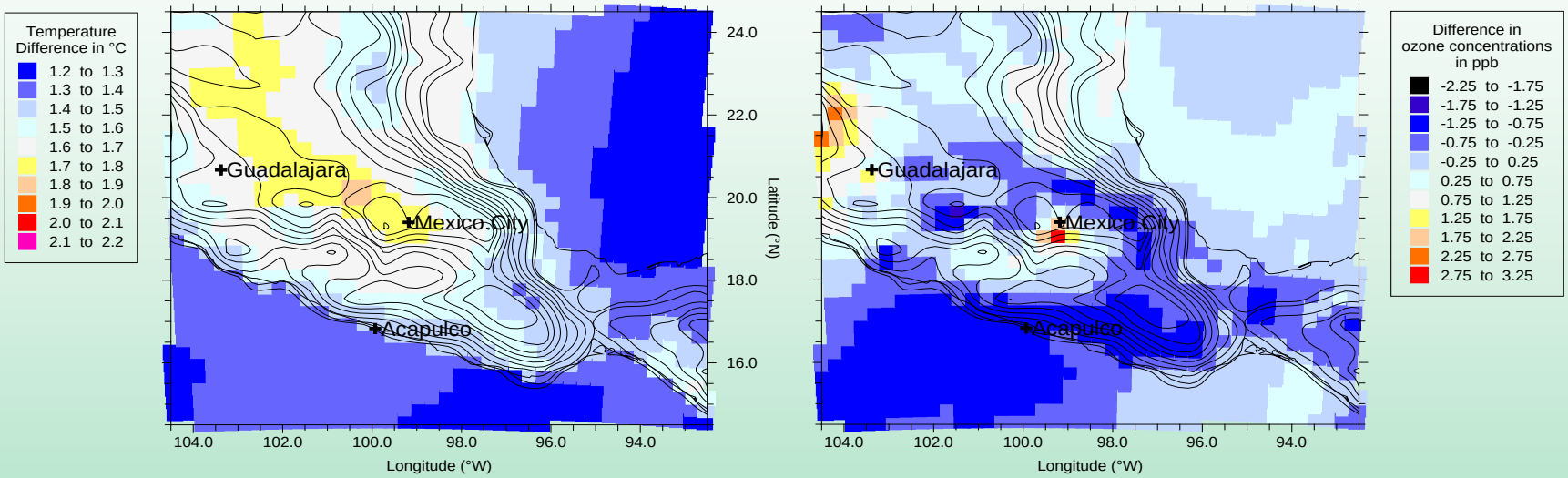
Resolution too coarse for regional impact analysis !

Peter Suppan, Institute for Meteorology and Climate Research (IMK-IFU)

HELMHOLTZ GEMEINSCHAFT

Universidad del Norte
Barranquilla / Colombia – 17 de Julio de 2009

Climate Change



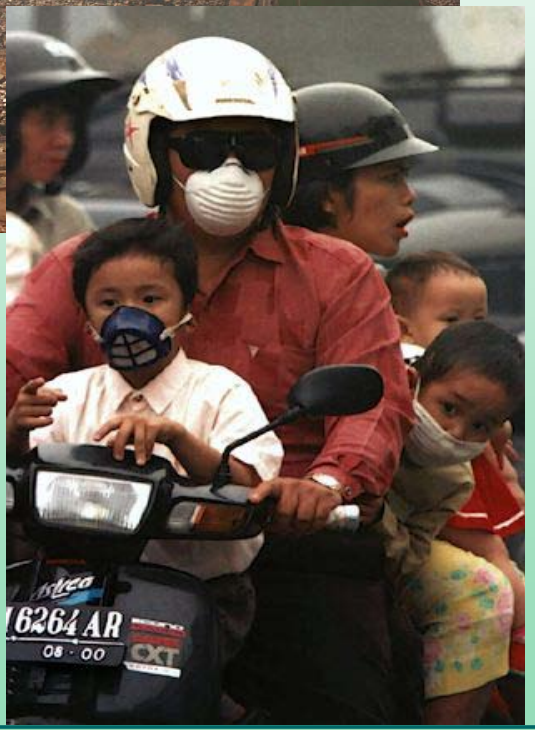
High resolution climate-chemistry simulations
- Mexico -

Peter Suppan, Institute for Meteorology and Climate Research (IMK-IFU)

Universidad del Norte
Barranquilla / Colombia – 17 de Julio de 2009

Impact on Air Quality

- Land use
- Energy
- Mobility
- Climate Change



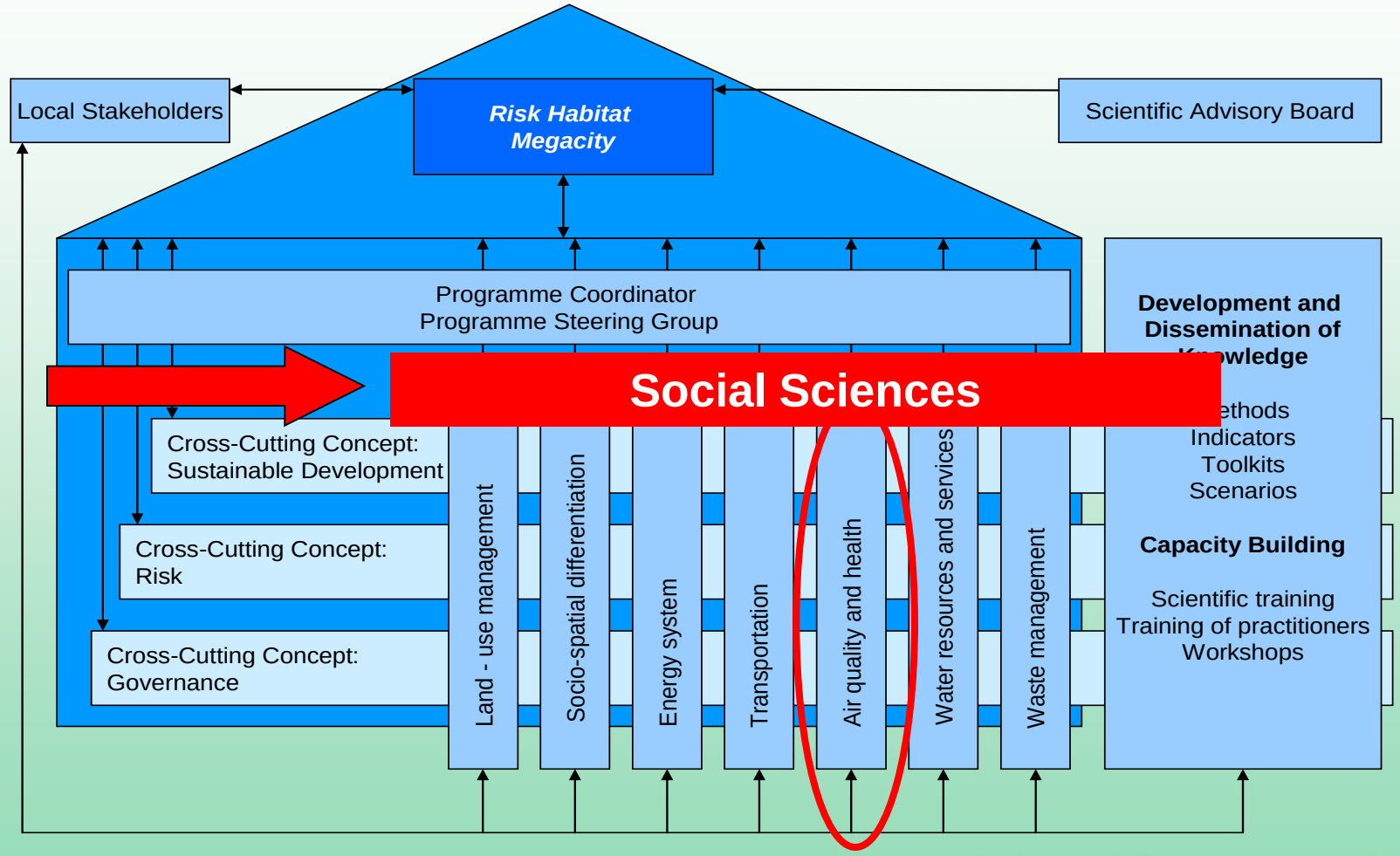
- Air Quality
- Health Impact

Integrated Approach

Objectives

- Contribute to the specification of sustainable objectives for the future development of mega-cities
- Characterize of risks, driving factors and consequences
- Design of strategies and instruments for risk management as key tools for a sustainable urban development
- Investigate on the regional-urban scale based on interdisciplinary research groups
- Develop of a science and experience platform for a technical and science based cooperation
- Capacity Building, exchange and transfer of knowledge

Architecture



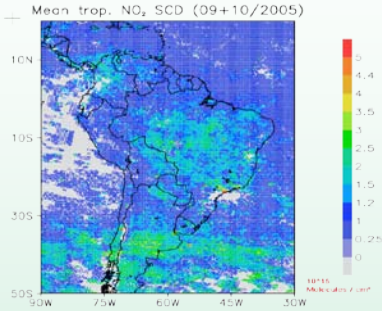
Risk Habitat Megacity
¿sostenibilidad en riesgo?

Research Questions

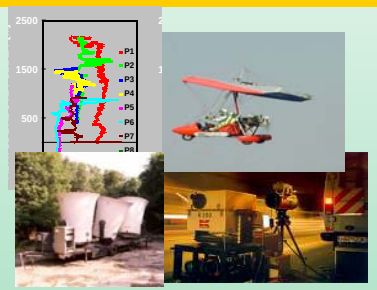
- How can we overcome the complexity of the interaction between different disciplines?
- Do we understand the complex links between emissions, air quality and health impact?
- How to act with the different scales?
- How can separate information platforms be linked to the development of an integrated approach to air quality assessment in mega cities?
- Which relationship exists between specific air pollutants like PM_{10} or NO_2 and the appearance of environment-related diseases?
- How to develop scenarios that they are in line with the climate change scenarios?

Integrated Approach

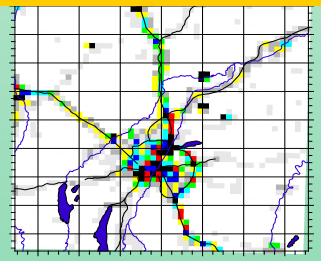
Satellite Data

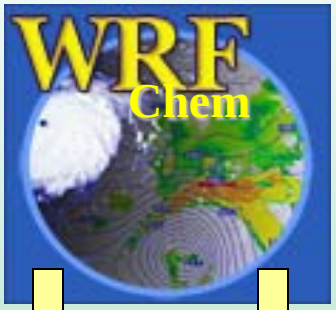


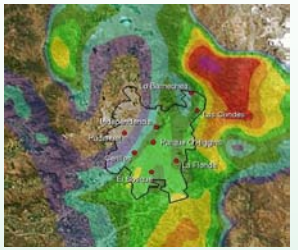
Measurement Data

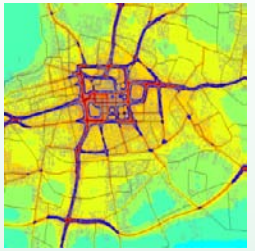


Emission Data









Air Quality

Scenario

Indicator

Mortality

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Subclinical Effects

Health Impact

Stakeholder

Peter Suppan, Institute for
Meteorology and Climate Research (IMK-IFU)

Conclusions

- Air quality issues need an holistic and interdisciplinary 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, congestion, waste, ...)
  - social risks (spatial segregation, health problems, …)
  - costs (healthcare system, transportation, production, ...)

Muchas gracias!

Cooperation Partner

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Rainer Schmitz, Ricardo Muñoz	*Universidad de Chile , Santiago de Chile (UdC)*
Michael Hagen	*Fondo Nacional de Salud (FONASA)*
Frank Baier	*Deutsches Luft- und Raumfahrtzentrum (DLR)*
Ulrich Franck	*Helmholtz Zentrum für Umweltforschung (UFZ)*
Annette Peters, Josef Cyrys	*Helmholtz Zentrum München (HMGU)*