Megacities: A Challenge for Air Quality Research

Peter Suppan

Institute for Meteorology and Climate Research
Atmospheric Environmental Research Division (IMK-IFU)
Forschungszentrum Karlsruhe GmbH

Garmisch-Partenkirchen, Germany

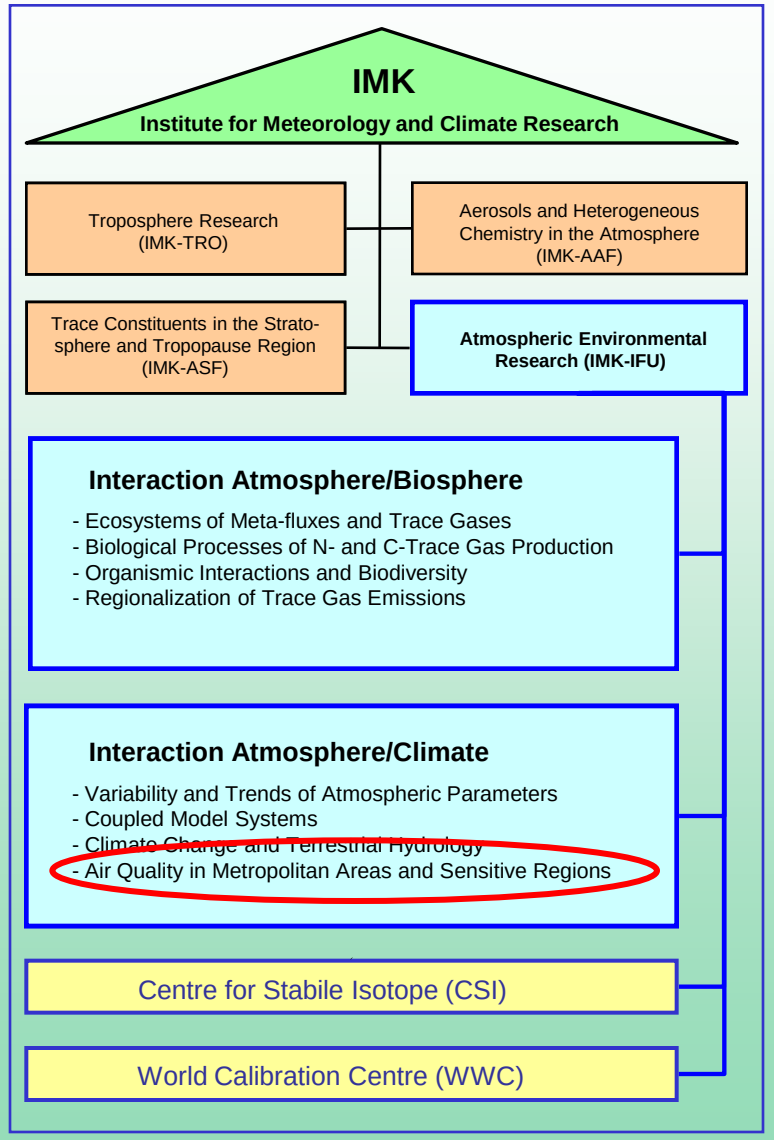
peter.suppan@imk.fzk.de

Overview

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

Institute for Meteorology and Climate Research (IMK-IFU)
Forschungszentrum Karlsruhe

Institute


IMK
Institute for Meteorology and Climate Research
Troposphere Research (IMK-TRO)
Aerosols and Heterogeneous Chemistry in the Atmosphere (IMK-AAF)
Trace Constituents in the Strato-sphere and Tropopause Region (IMK-ASF)
Atmospheric Environmental Research (IMK-IFU)
Interaction Atmosphere/Biosphere
- Ecosystems of Meta-fluxes and Trace Gases
- Biological Processes of N- and C-Trace Gas Production
- Organismic Interactions and Biodiversity
- Regionalization of Trace Gas Emissions
Interaction Atmosphere/Climate
- Variability and Trends of Atmospheric Parameters
- Coupled Model Systems
- Climate Change and Terrestrial Hydrology
- Air Quality in Metropolitan Areas and Sensitive Regions
Centre for Stabile Isotope (CSI)
World Calibration Centre (WWC)

Location:
FZK & IMK-IFU

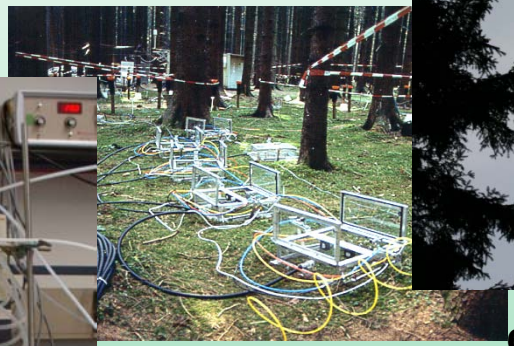
Atmospheric Environmental Research:

Think Globally - Assess Regionally - Act Locally

(source: IPCC 2001, WG1 Report, Summary)

The Challenge

organisms
(laboratory meas.)



plot scale
(chamber meas.)

ecosystem scale
(tower meas./
remote sensing)

regional scale
(aircraft meas.)

global scale
(remote sensing)

Large (relevant) Projects

- ✓ ENTRANCE (ENvironmental TRANsition of China's Ecosystems under predicted global changes)
- ✓ TERENO (TERrestrial ENvironmental Observatories; *Long-term Observations and Regional Earth System Modelling*)
- ✓ RHM (Risk-Habitat-Megacity; *Urbanization and sustainable development of mega cities*)

and others

Environmental Facts

Air pollution as the most significant environmental challenge, followed by congestion issues

(Survey with 500 megacity - „stakeholders“)

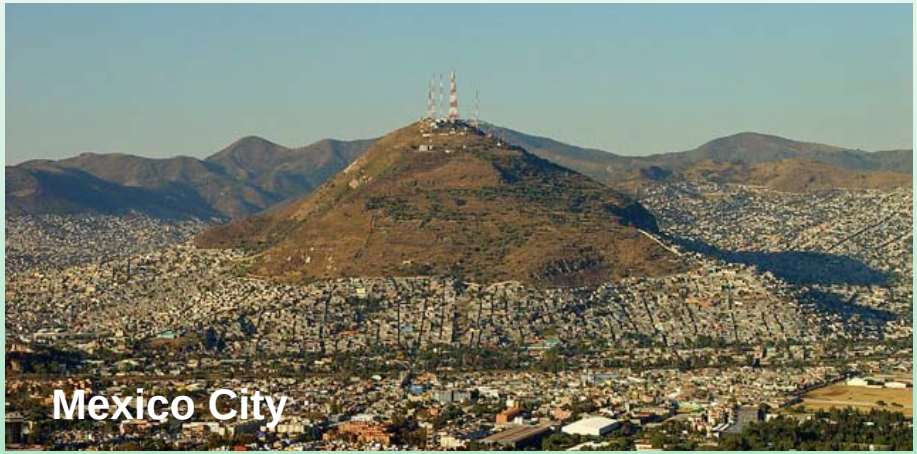
but

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

Source: Siemens, 2007

Problems and Risks

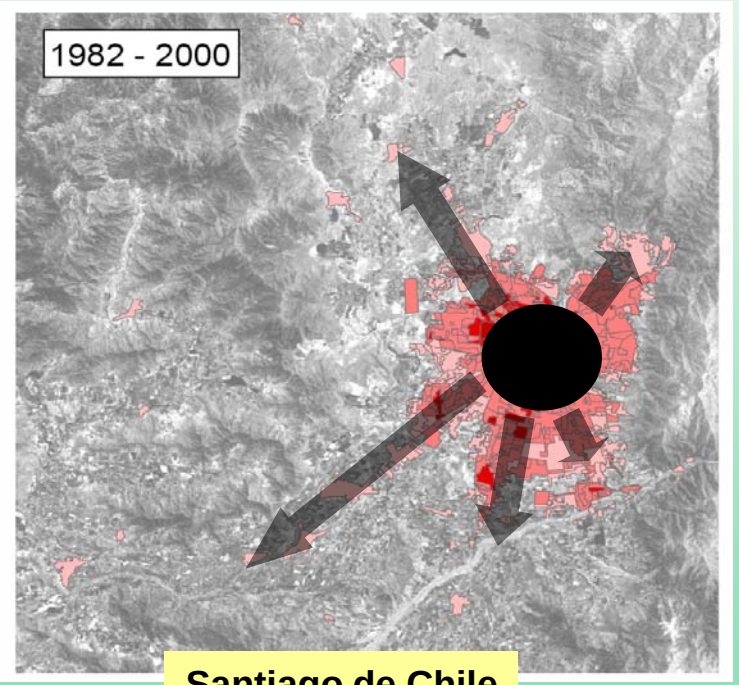
- Land use



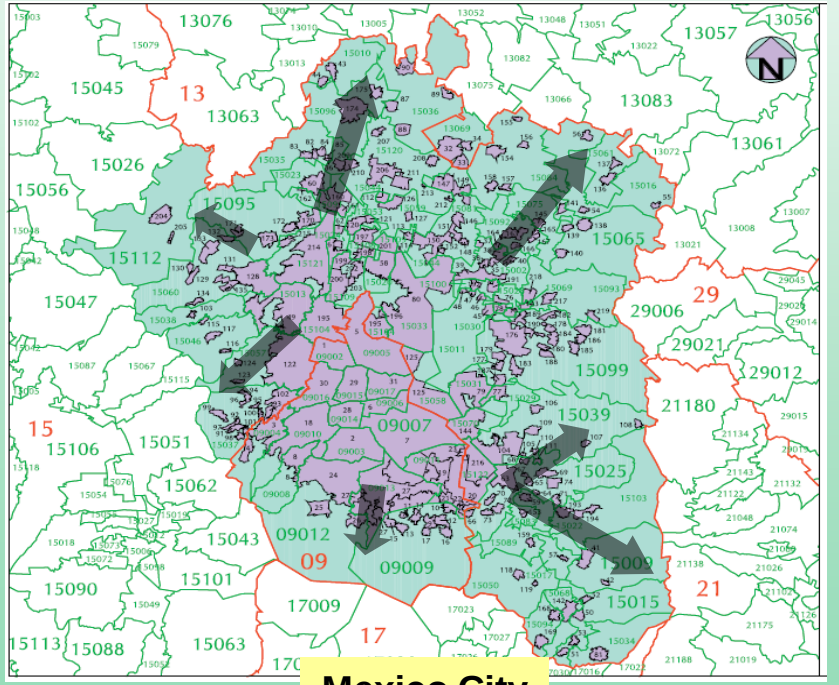
Land Use Change

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



Santiago de Chile

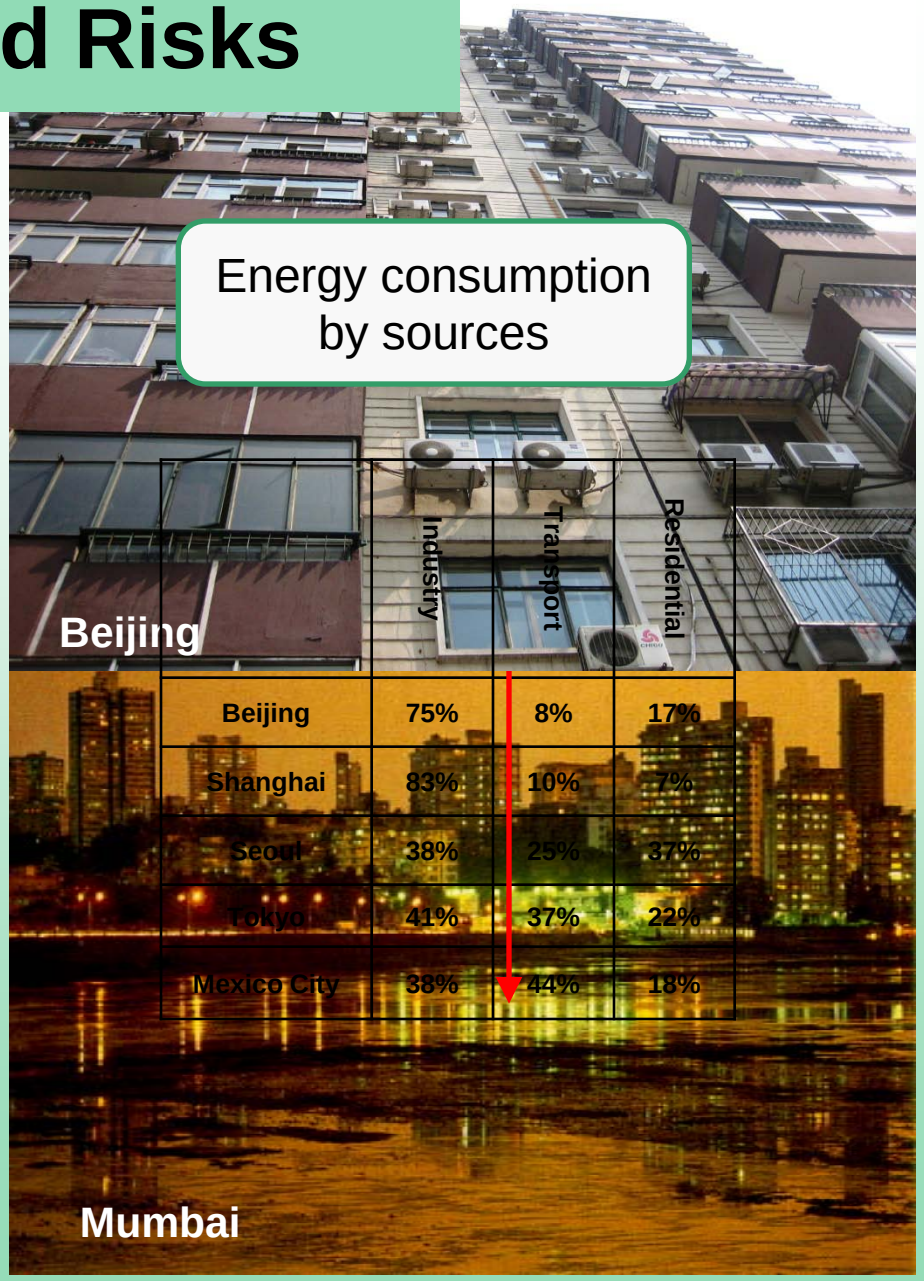


Mexico City

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

Problems and Risks

- Land use
- Energy

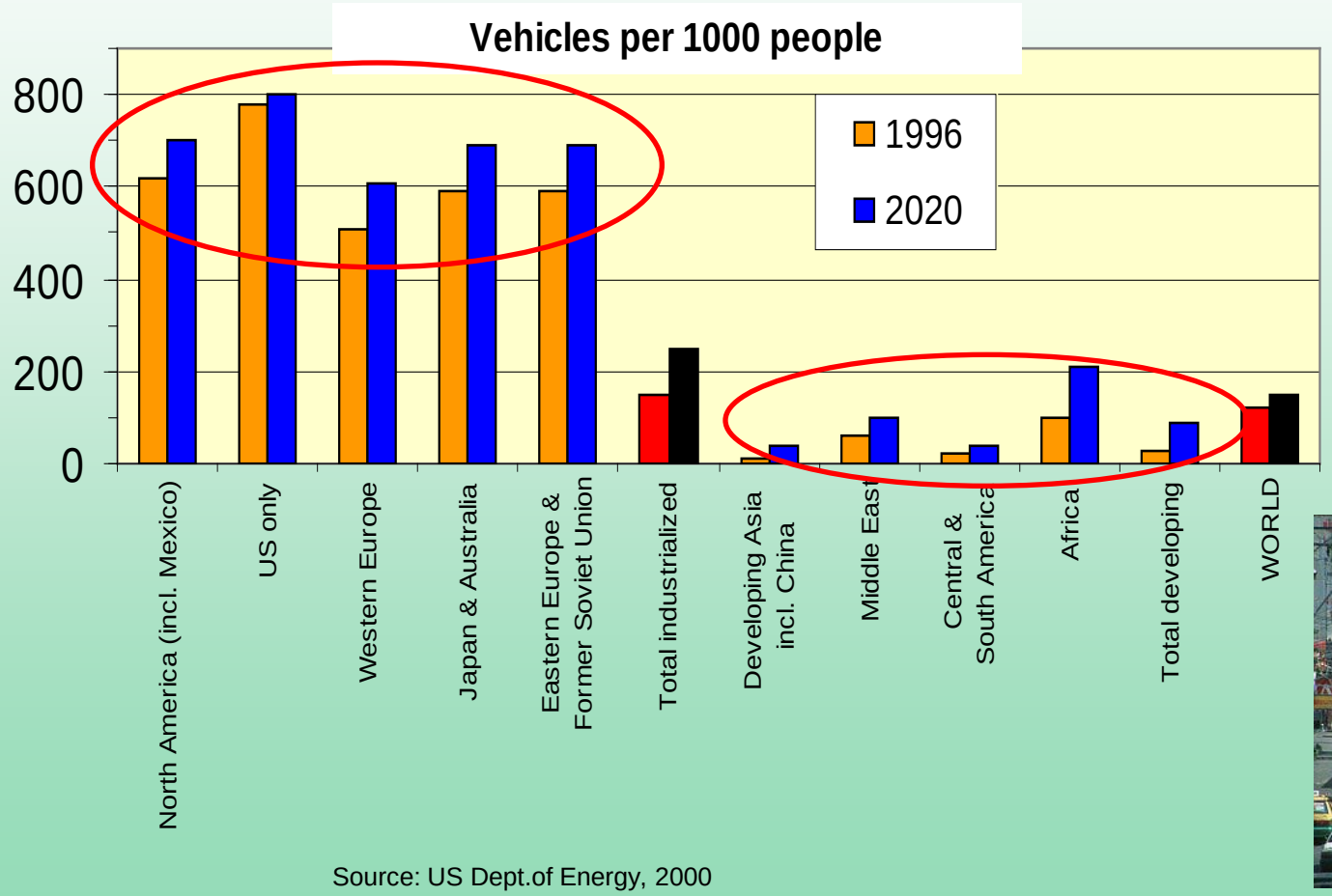


	Industry	Transport	Residential
Beijing	75%	8%	17%
Shanghai	83%	10%	7%
Seoul	38%	25%	37%
Tokyo	41%	37%	22%
Mexico City	38%	44%	18%

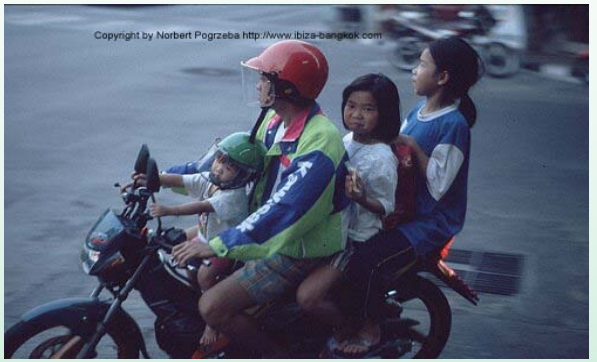
Problems and Risks

- Land use
- Energy
- Mobility

Traffic



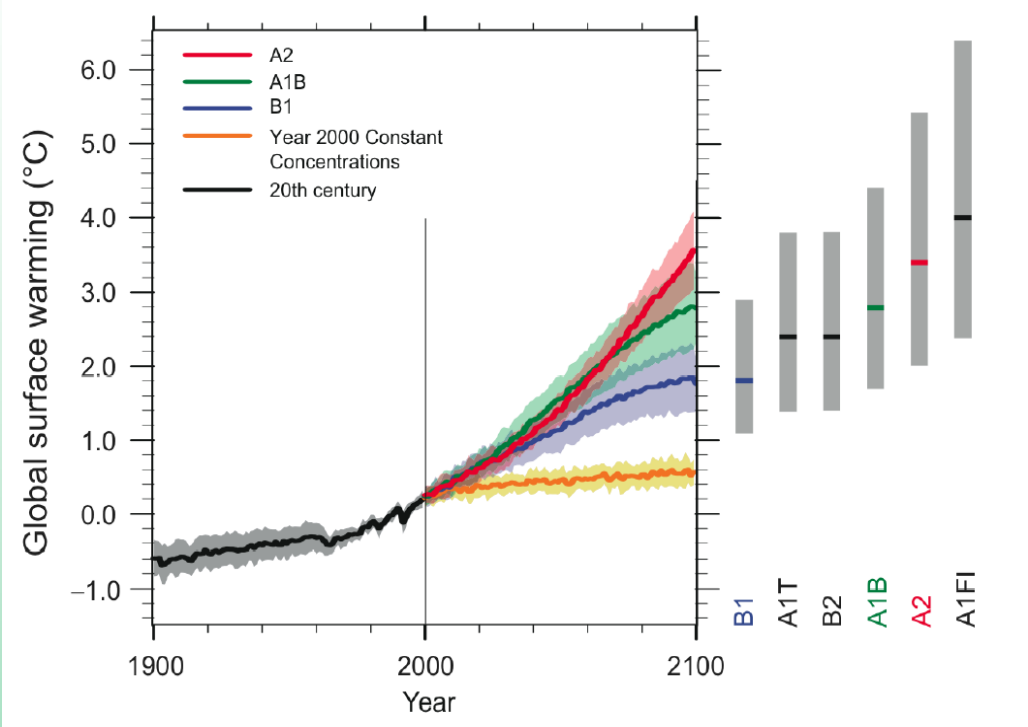
Source: US Dept.of Energy, 2000



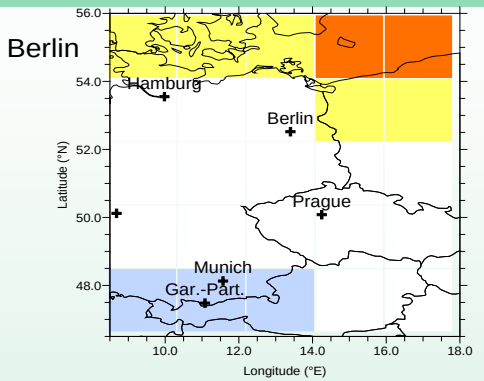
Traffic Volume in 1996 and 2020

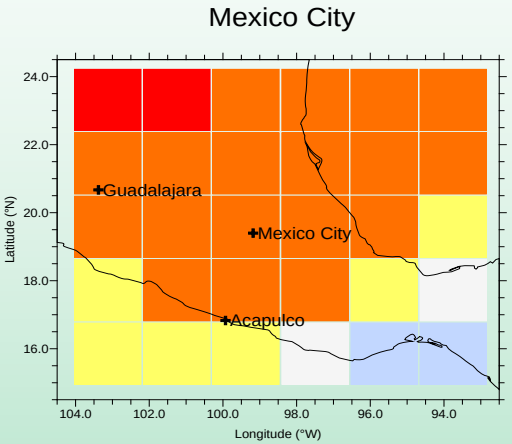
Problems and Risks

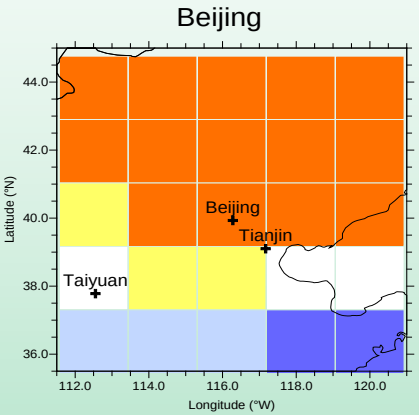
- Land use
- Energy
- Mobility
- Climate Change

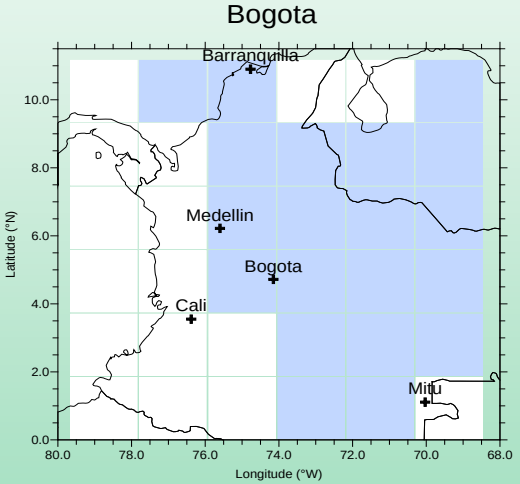


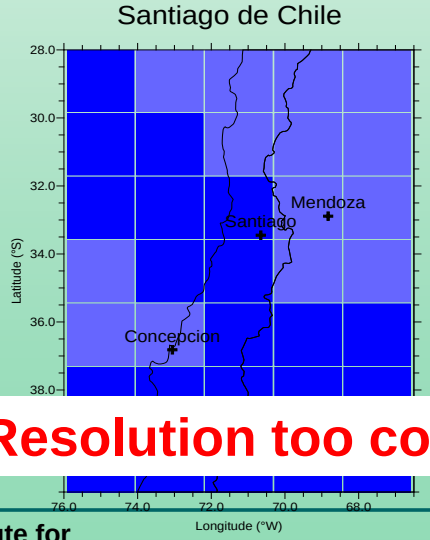
Climate Change Impact











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

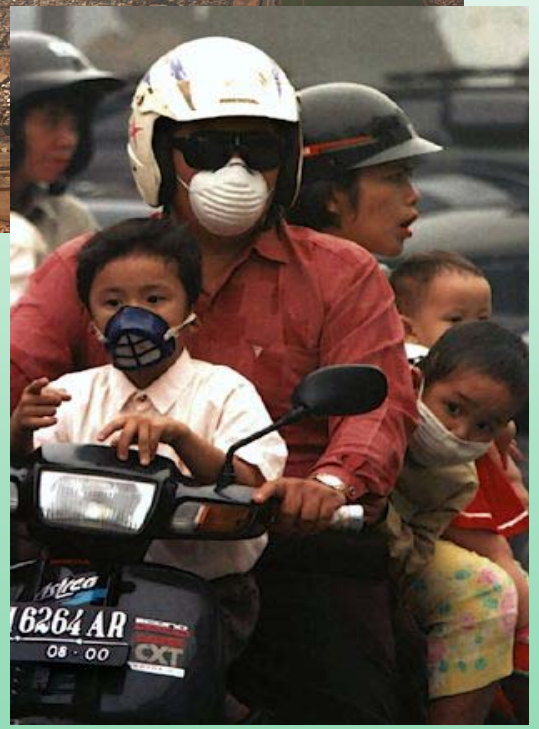
Climate change impact on urban agglomerations

⇒ Resolution too coarse for regional impact analysis !

Problems and Risks

- Land use
- Energy
- Mobility
- Climate Change

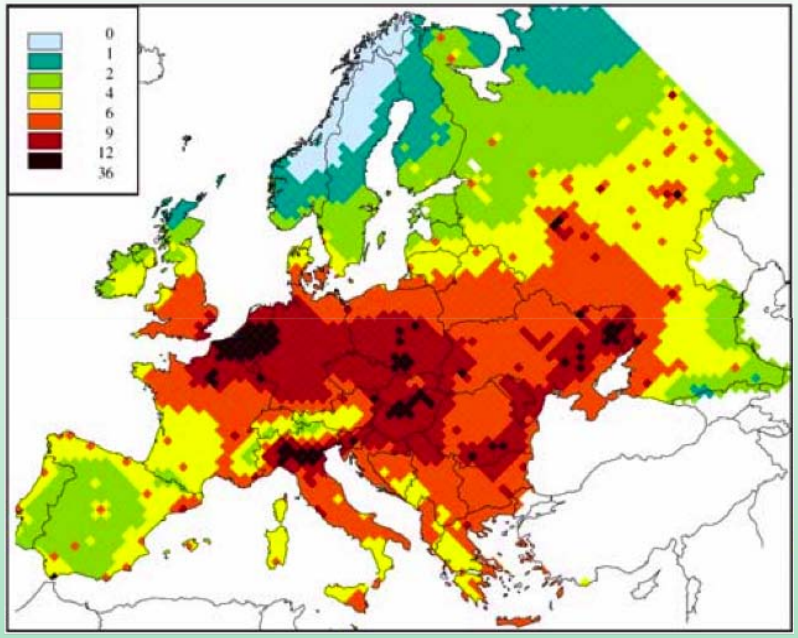
- Air Quality
- Health Impact



integrated approach

Health Facts

2000



Health impact and air pollution

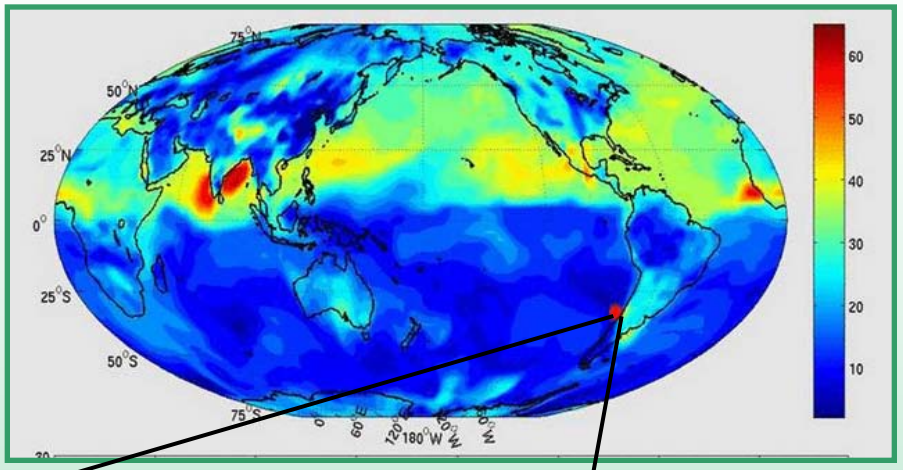
Decrease in life expectancy in months due to anthropogenic $PM_{2.5}$

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

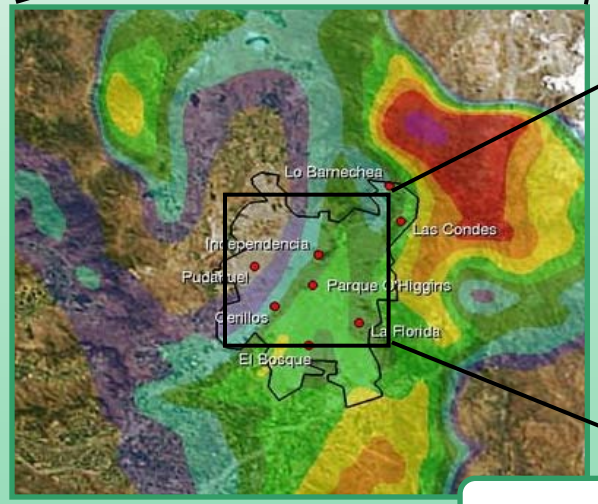
Research Questions

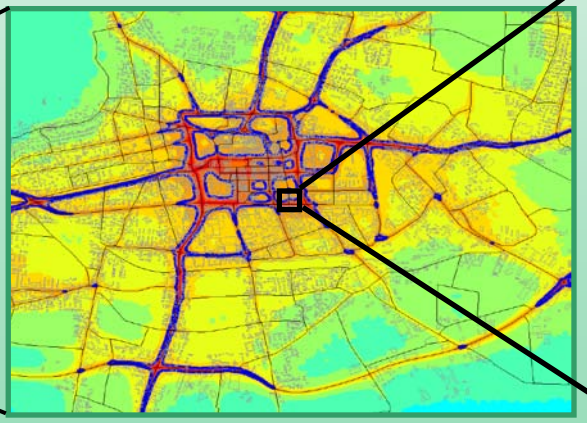
- How can we overcome the complexity of the interaction between different disciplines?
- Do we understand the complex links between emissions, air quality and health impact?
- How can act with the different scales?
- How can separate information platforms be linked to the development of an integrated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

Scales



Scales	Pollutants
Global	GHG, O_3
Regional	O_3, PM2.5
Local	PM, NO_2, CO

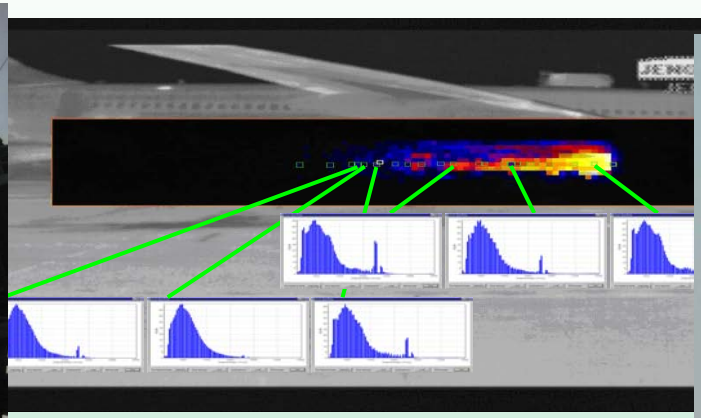




Models

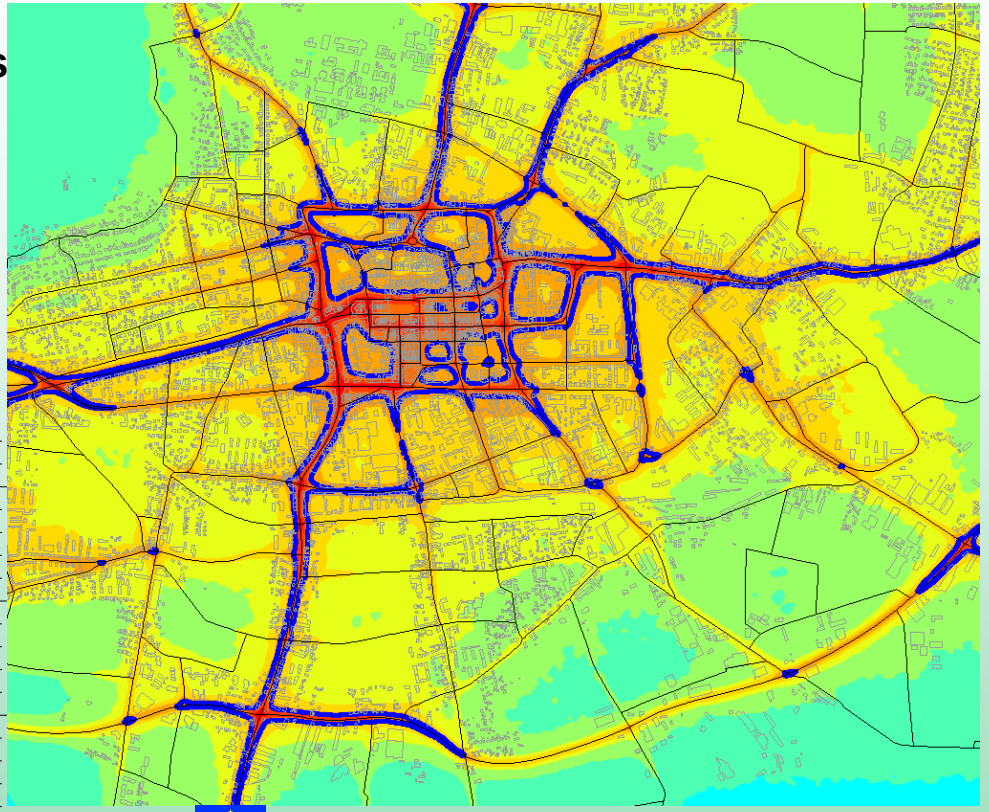
Measurements

Measurement Platforms

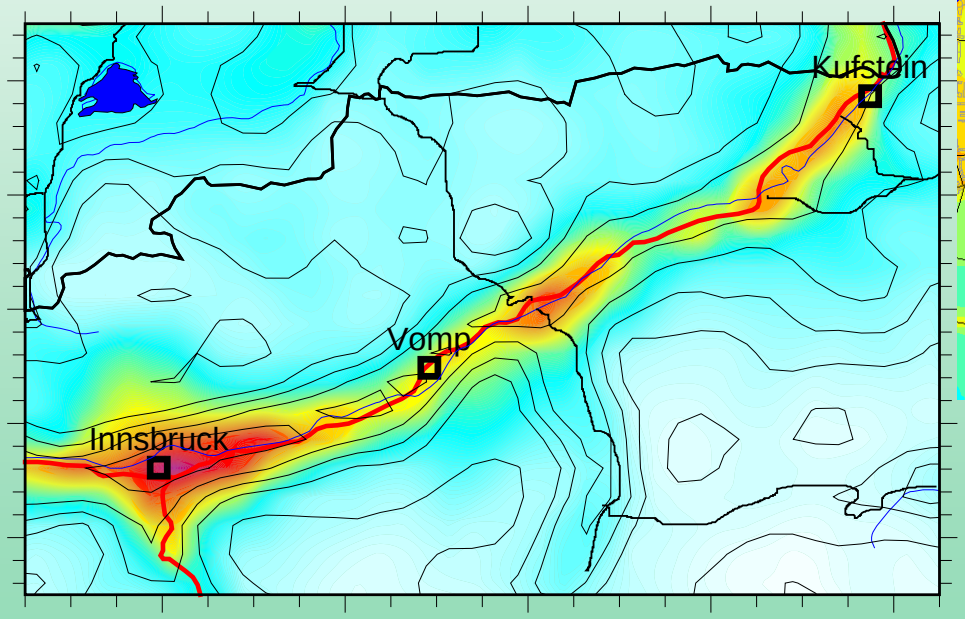


Coupling of Scales

Threshold exceedances



Meso-scale modeling e.g. NO_2 with MCCM



Source: EU-LIFE Project
Klagenfurt Graz Bozen

KAPA GS

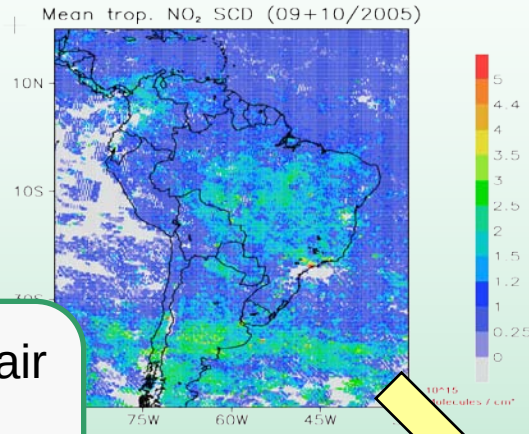
Micro-scale modelling e.g. NO_2 with GRAL

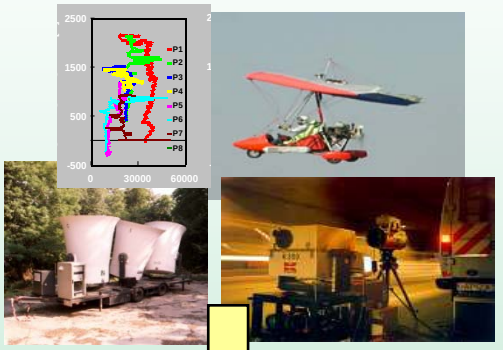
Methodology

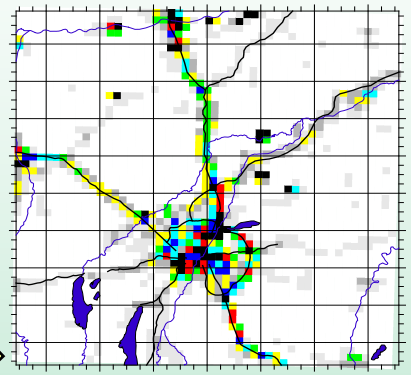
Satellite data

Measurement data

Emission data



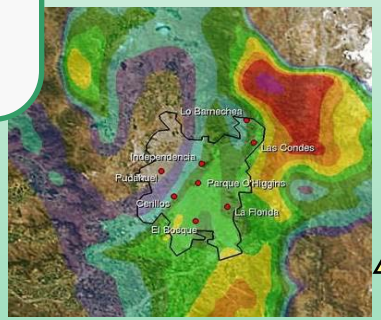




integrated air quality assessment studies

WRF Chem

GRAL

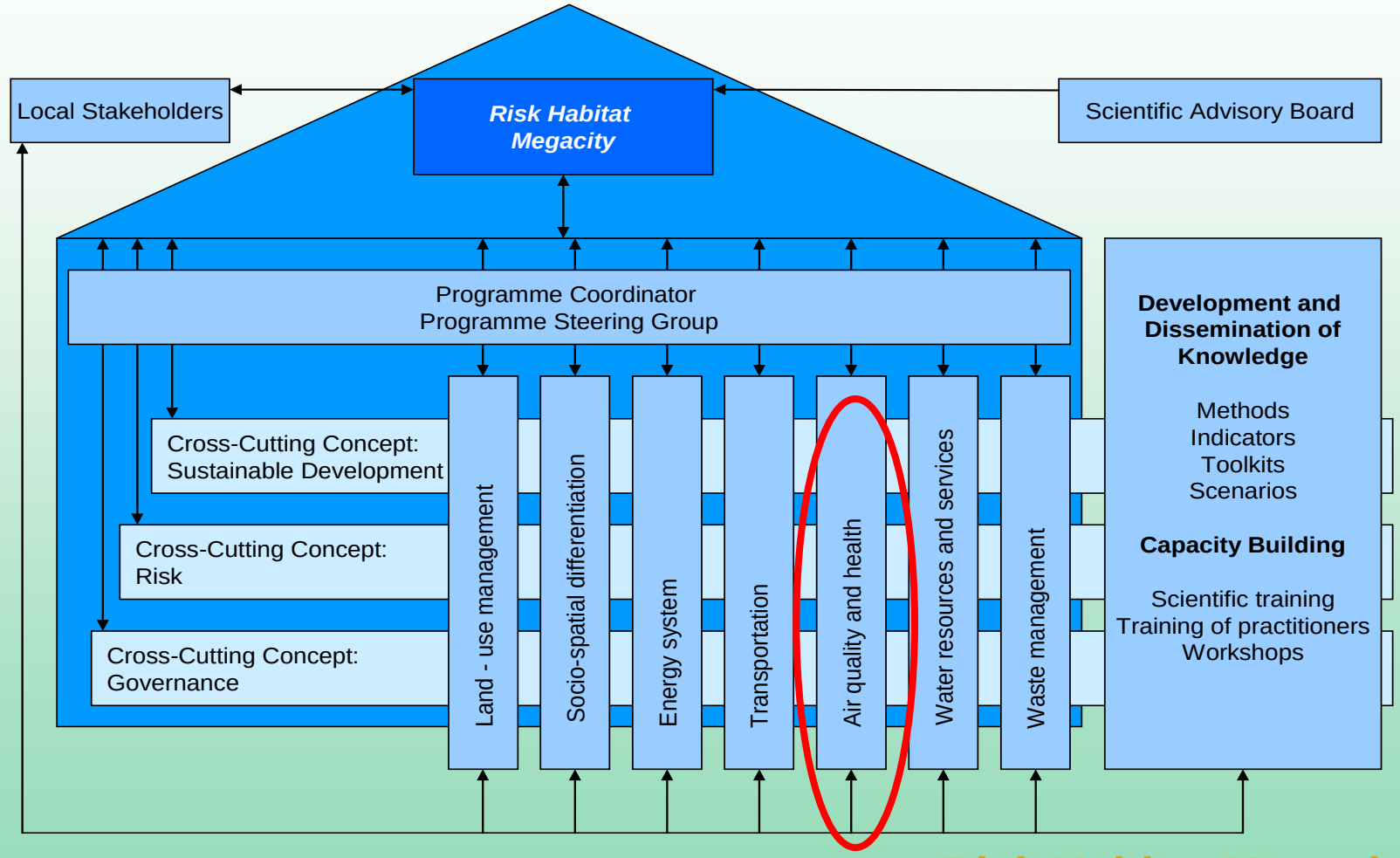


Air quality

science based decision support

Measures

Architecture



Risk Habitat Megacity
¿sostenibilidad en riesgo?

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, ...)

Thank you very much for your attention