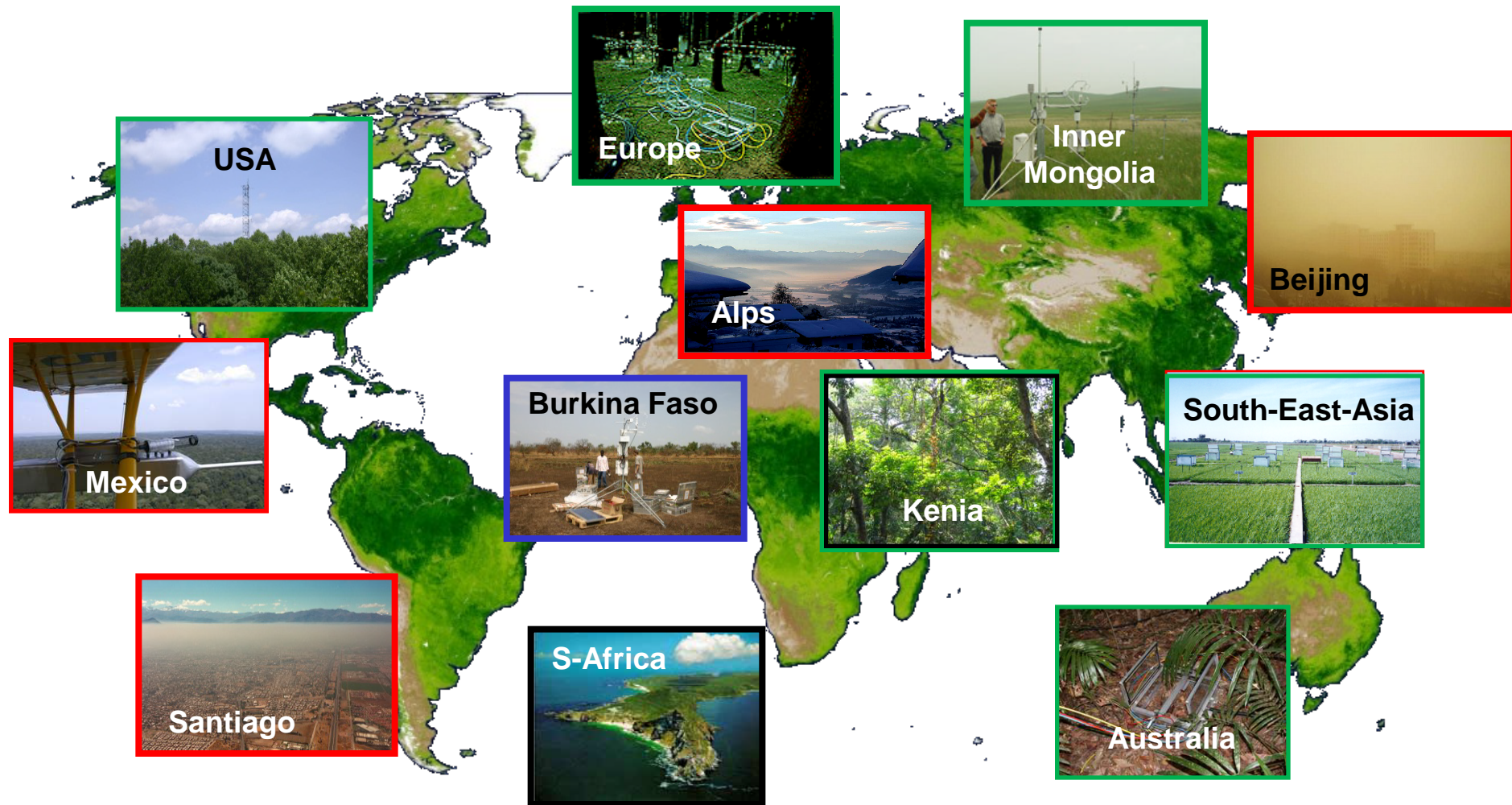


Air Quality in Megacities: A Challenge for Interdisciplinary Research

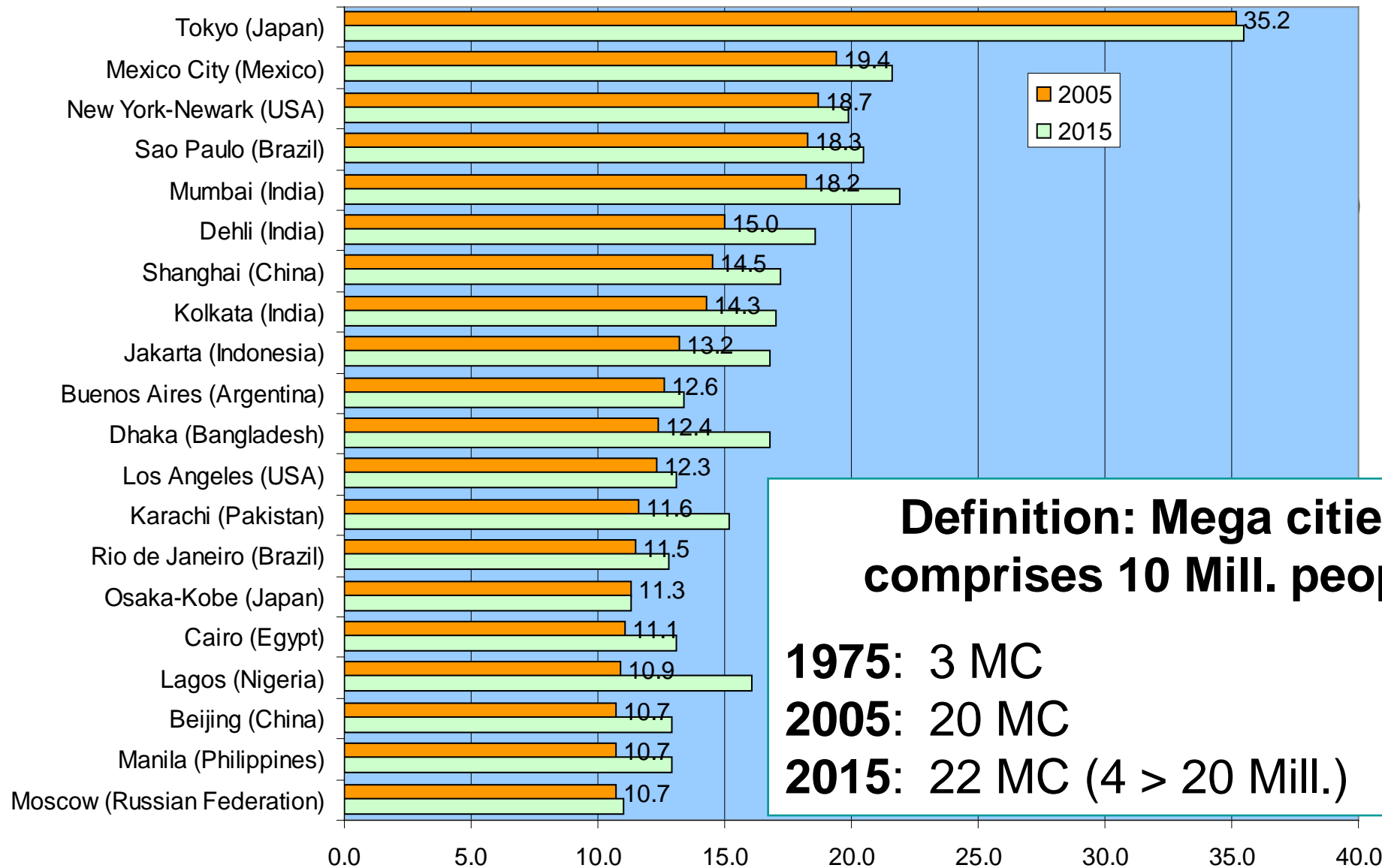
*P. Suppan, S. Emeis, Klaus Schäfer & R. Forkel
Institute for Meteorology and Climate Research
Atmospheric Environmental Research Division (IMK-IFU)
Forschungszentrum Karlsruhe GmbH
Kreuzeckbahnstr. 19
82467 Garmisch-Partenkirchen, Germany*

IMK-IFU topics:

Air quality, atmosphere-biosphere exchange,
hydrology, long-term trends



Megacities



**Definition: Mega cities
comprises 10 Mill. people**

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

Problems and risks in megacities

➤ Energy

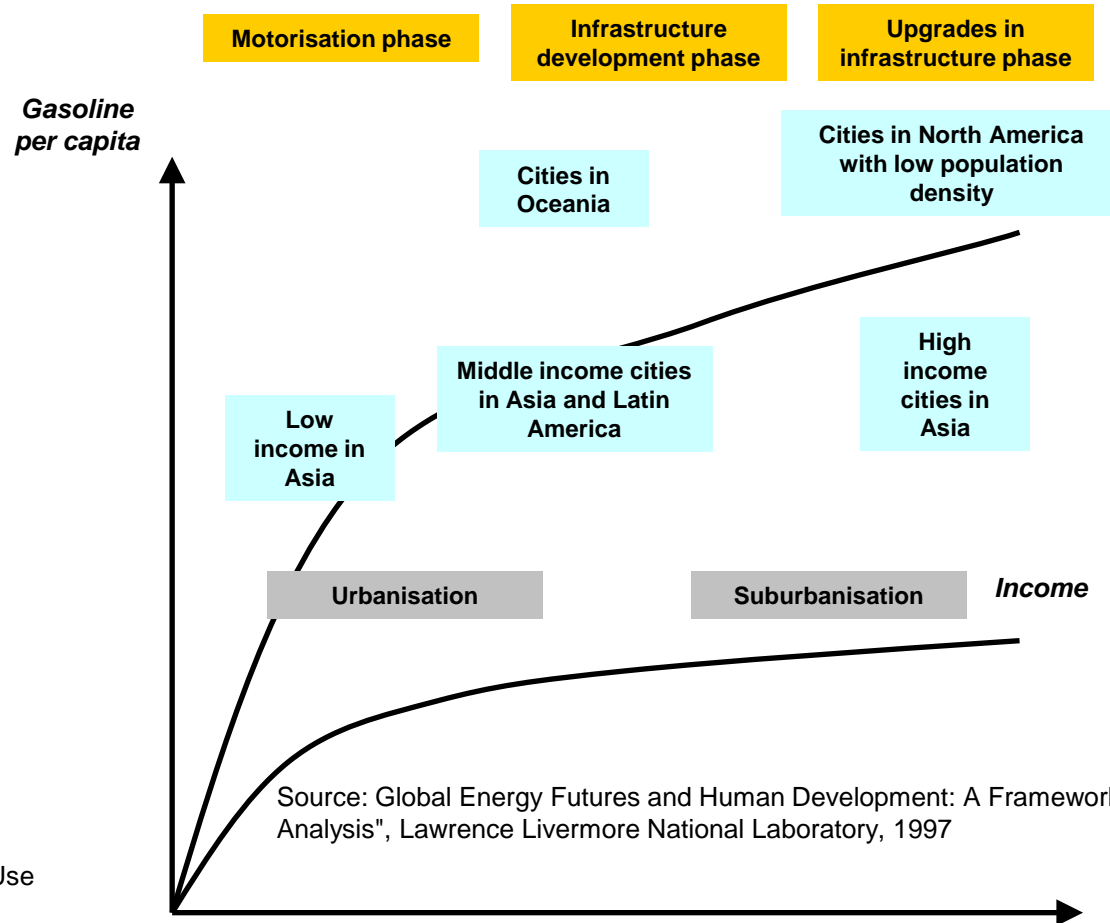


Energy consumption

Energy consumption by sources

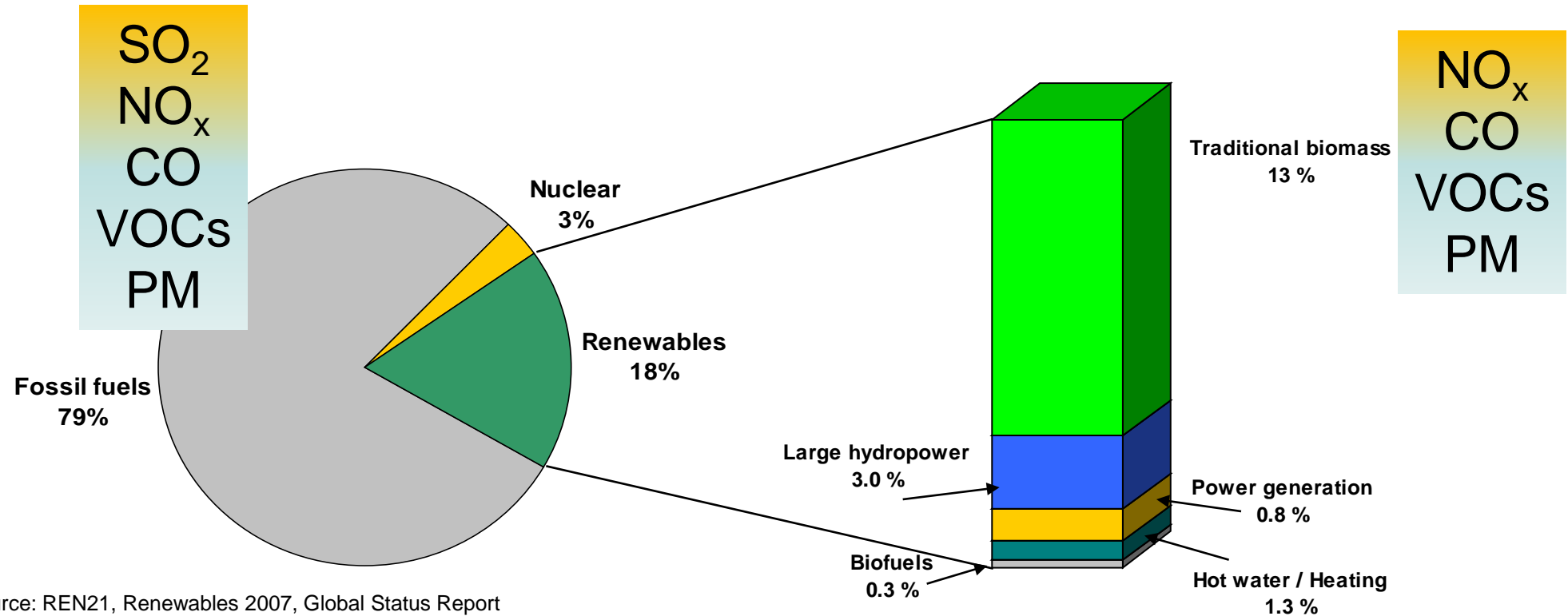
	Industry	Transport	Residential
Beijing	75%	8%	17%
Shanghai	83%	10%	7%
Seoul	38%	25%	37%
Tokyo	41%	37%	22%
Mexico City	38%	44%	18%

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



Source: Global Energy Futures and Human Development: A Framework for Analysis", Lawrence Livermore National Laboratory, 1997

Global energy consumption



Source: REN21, Renewables 2007, Global Status Report



Fossil fuels and biomass both affects air quality

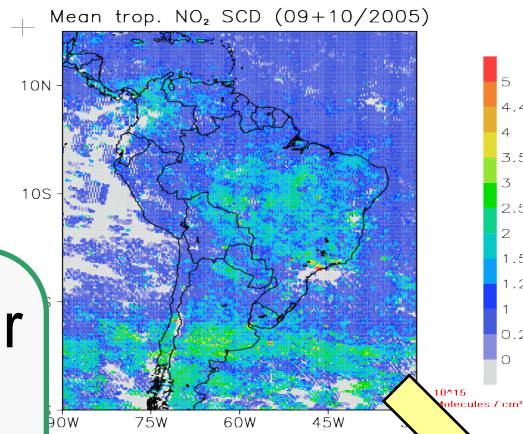
Research focus with respect to megacities

Air Quality in Metropolitan Areas and Sensitive Regions

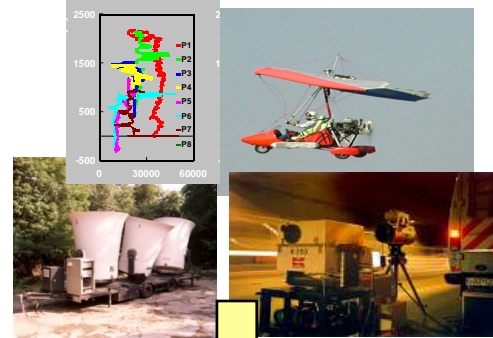
- **Interactions between urban/suburban/rural regions and their feedback mechanisms to air quality (e.g. urban heat islands and other secondary circulations)**
- **Development and validation of innovative techniques for the assessment of emissions and air quality (e.g. road traffic, airports) incl. remote sensing and inverse modelling**
- **Assessment of meteorological influences such as mixing-layer height (e.g. ceilometer and RASS measurements on the boundary-layer structure) on air quality**
- **Coupling of models (MCCM, WRFchem, micro scale models), e.g. for the analysis of the present state and the assessment of possible mitigation/adaptation strategies**
- **Impact of regional climate change on air quality and human health**
- **Interdisciplinary project “Risk Habitat Megacity” with the topic “Air Quality and Health”; anchor city Santiago de Chile in co-operation with Universidad de Chile**

Methodology

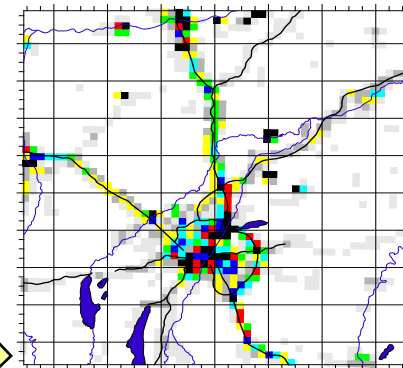
Satellite data



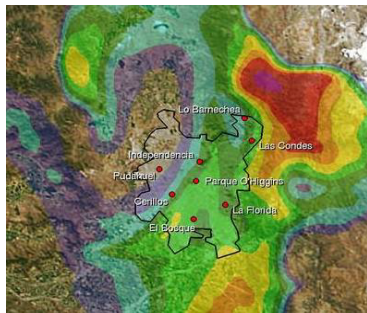
Measurement data



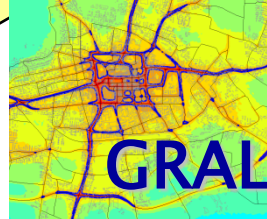
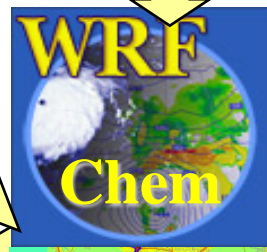
Emission data



integrated air quality assessment studies



Air quality

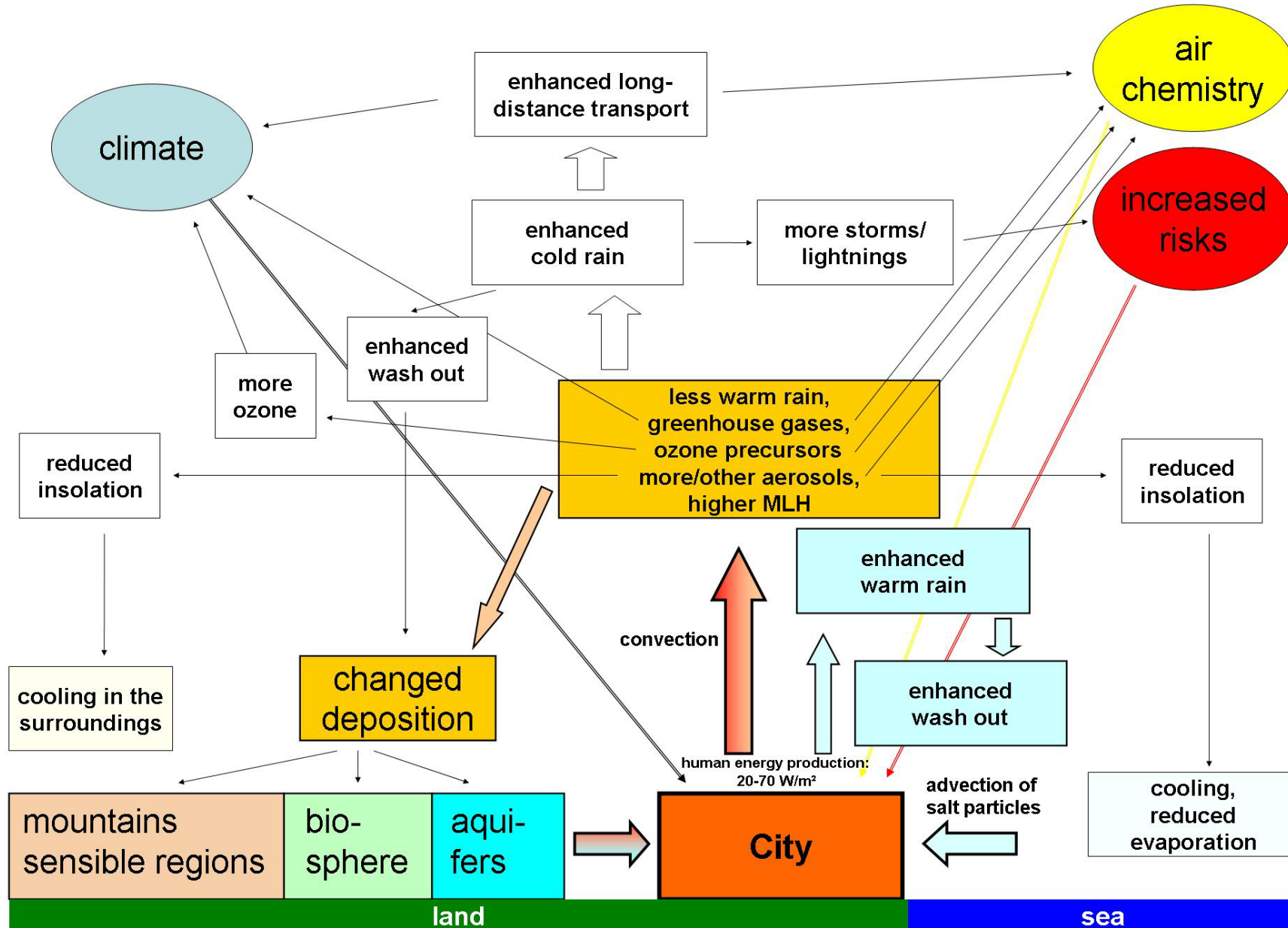


science based decision support



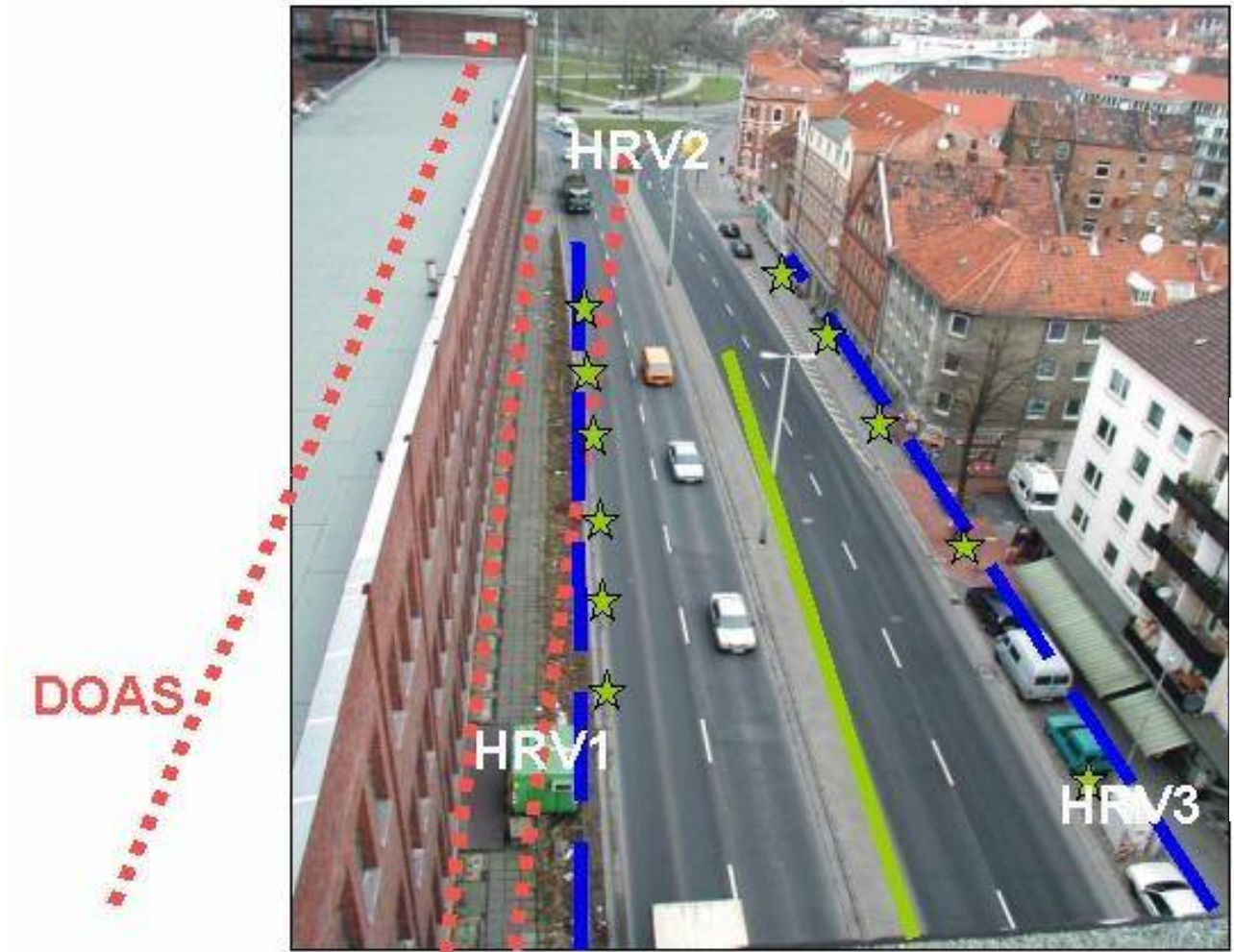
Measures

Urban-rural interactions/urban heat island



© 2008 Stefan Emeis, IMK-IFU

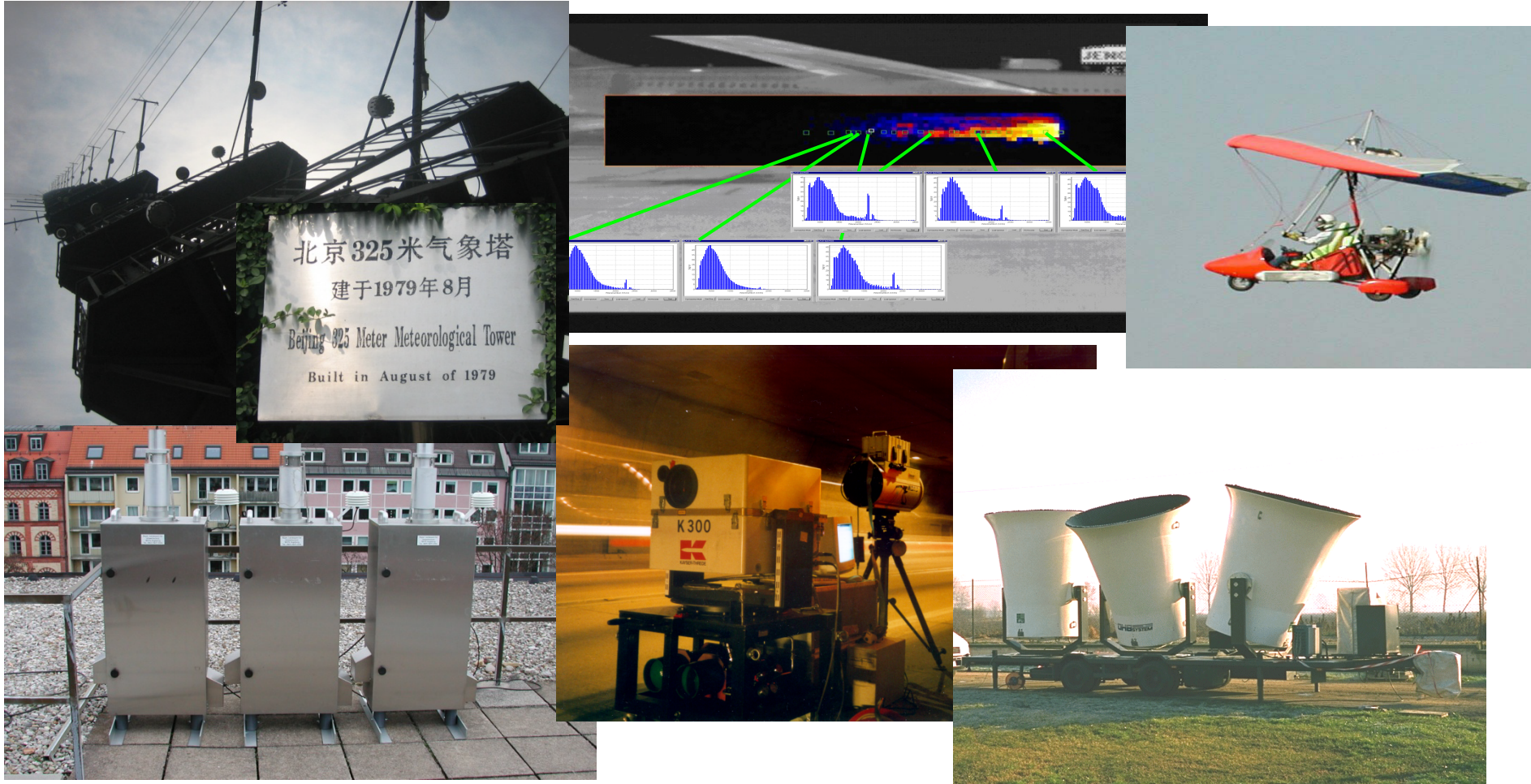
Remote sensing of traffic emissions



**SF6 line
source and
sampling
sites**

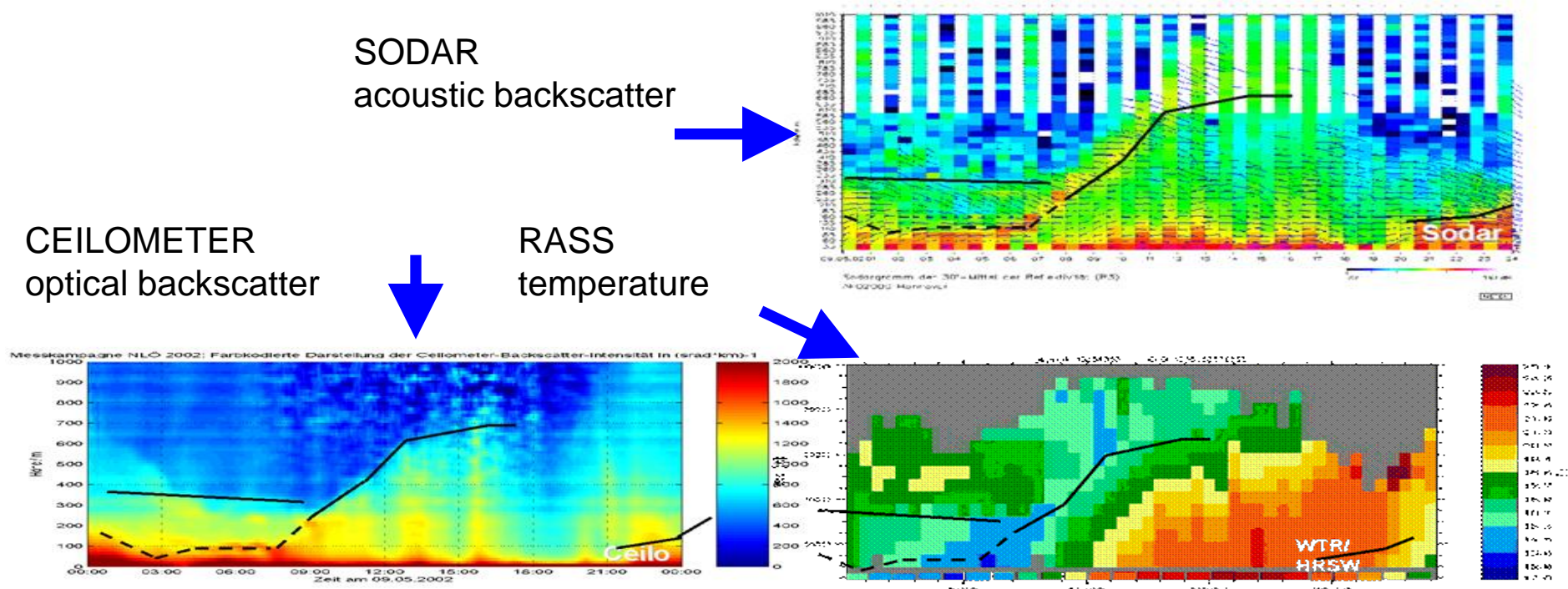
FTIR

Measurement platforms



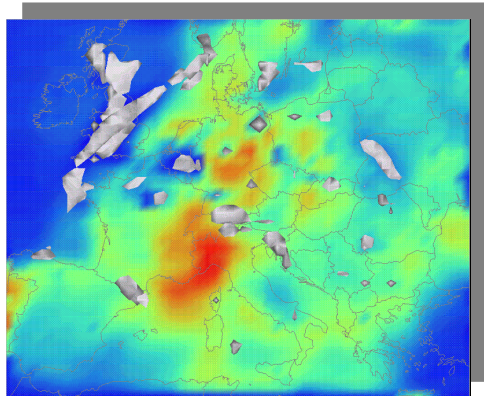
Assessment of meteorological conditions, e.g. vertical profiling

Mixing height measurements

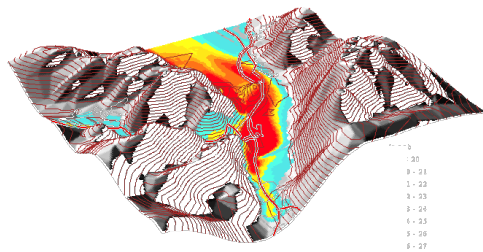


Emeis, S., Chr. Münkel, S. Vogt, W.J. Müller, K. Schäfer, 2004: Atmospheric boundary-layer structure from simultaneous SODAR, RASS, and ceilometer measurements. *Atmos. Environ.*, 38, 273-286.

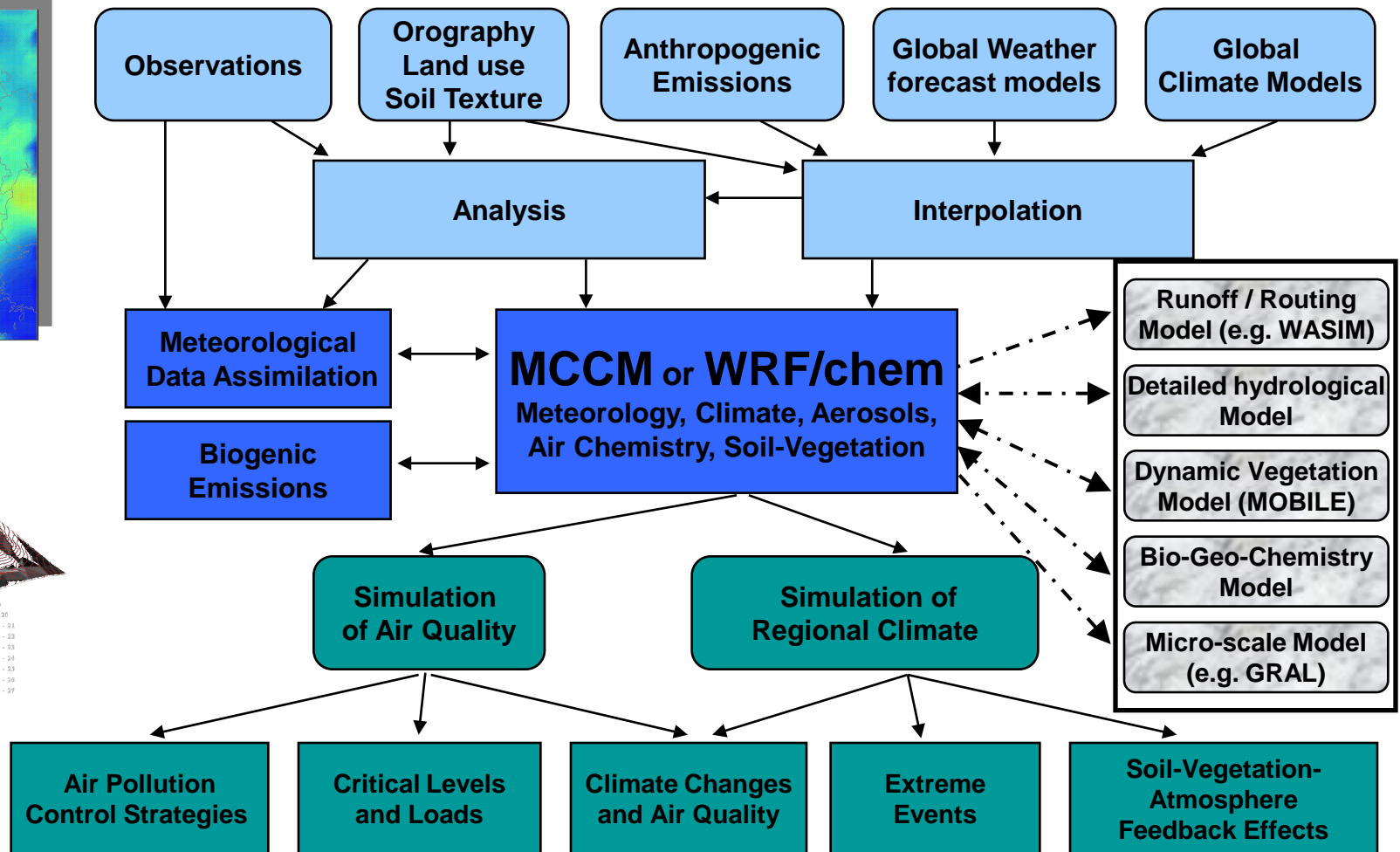
Coupling of models/Modelling System



regional



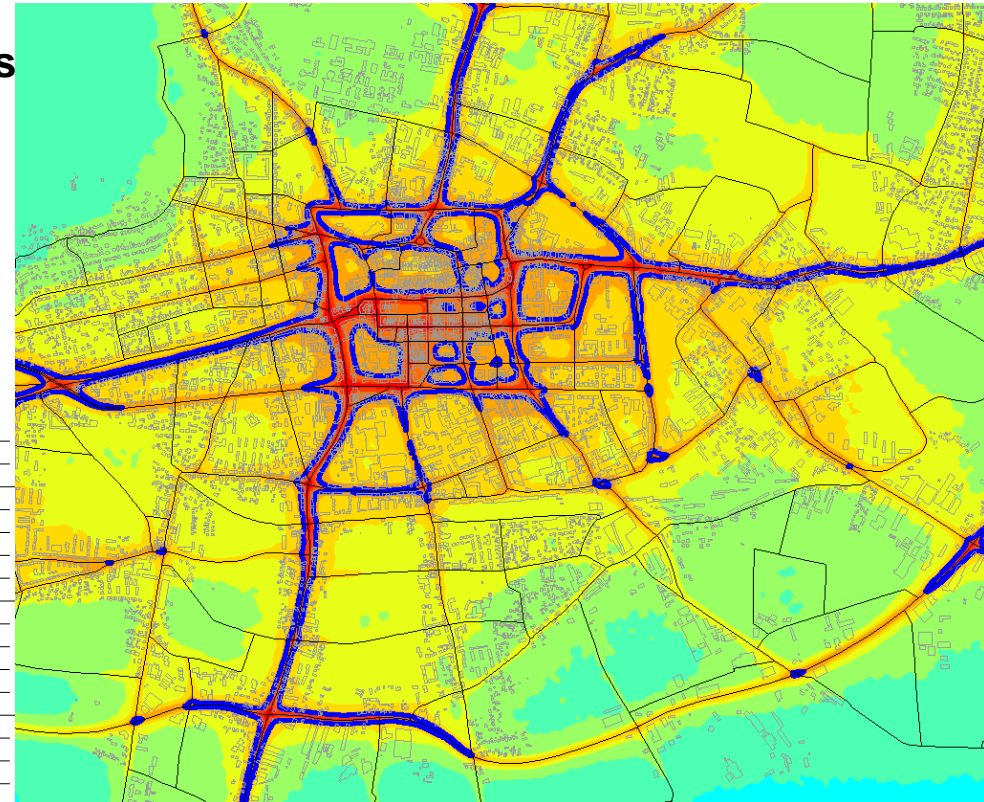
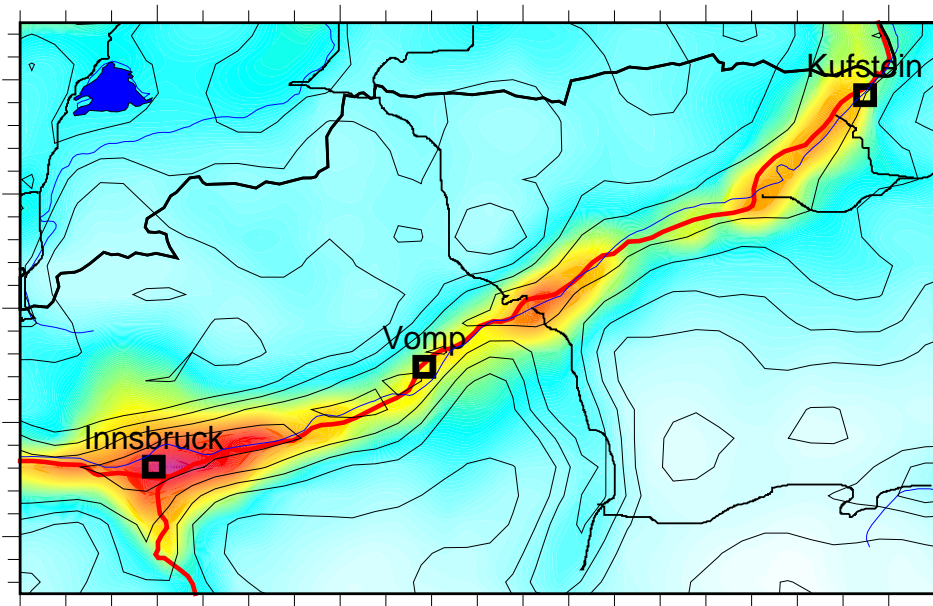
local



Coupling of scales in modelling

Threshold exceedances

Meso-scale modeling
e.g. NO₂ with MCCM



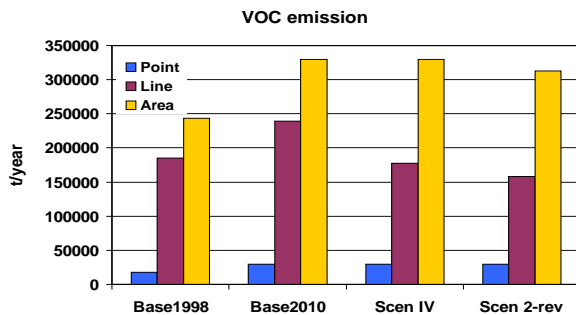
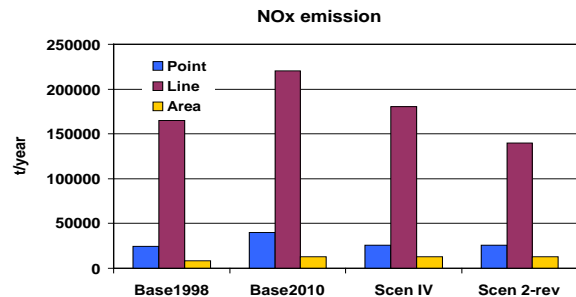
Source: EU-LIFE Project
Klagenfurt Graz Bozen

KAPA GS

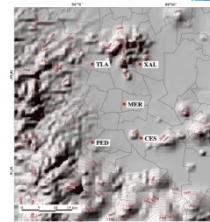
Micro-scale modelling
e.g. NO₂ with GRAL

Adaptation Strategies

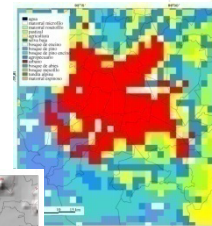
e.g. Mexico City



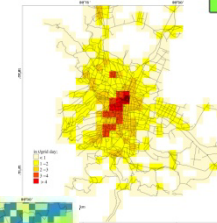
Basic information on present emissions and emissions of reduction measures



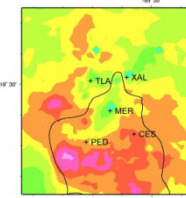
Topography



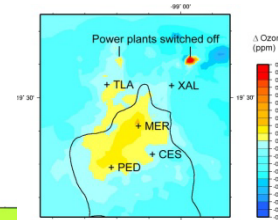
NOx Emissions



Land use

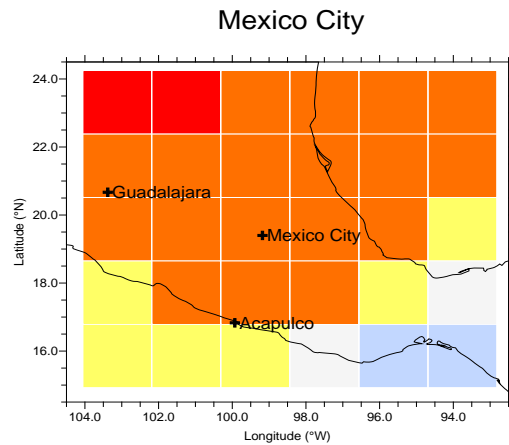


O₃-concentrations in 2010

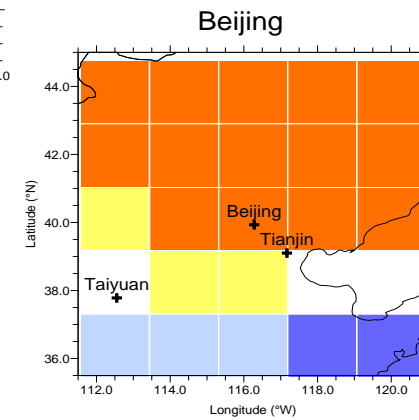
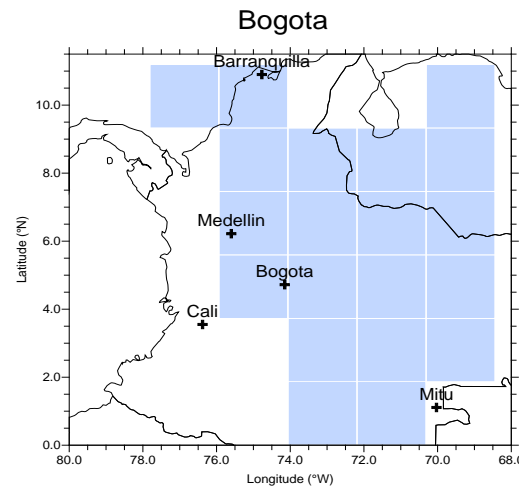
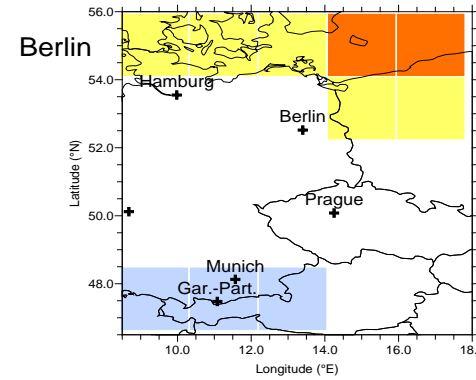
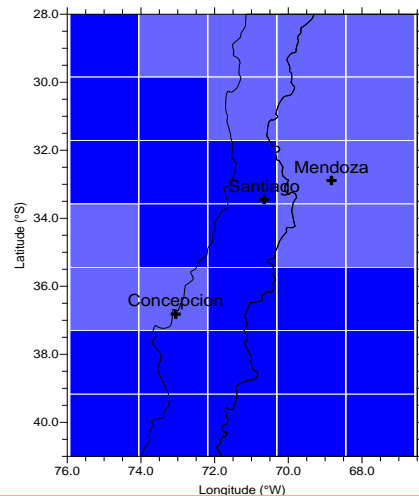


O₃-difference in 2010

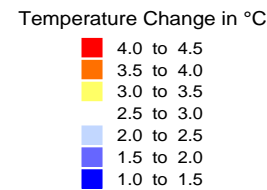
Climate Change Impact



Santiago de Chile



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

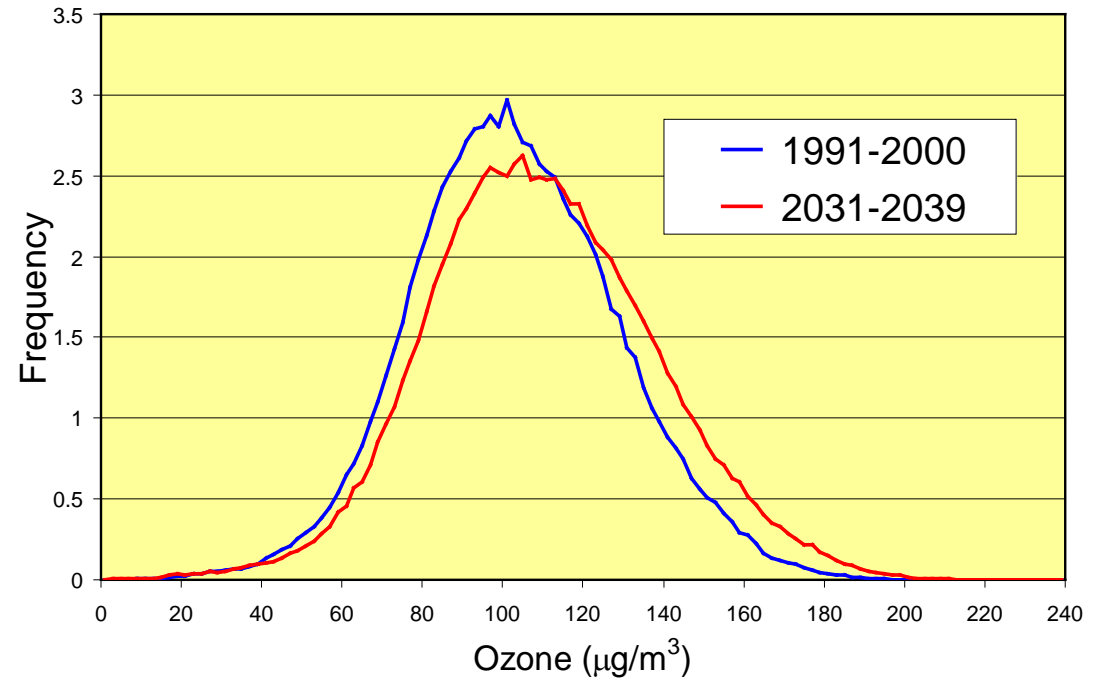
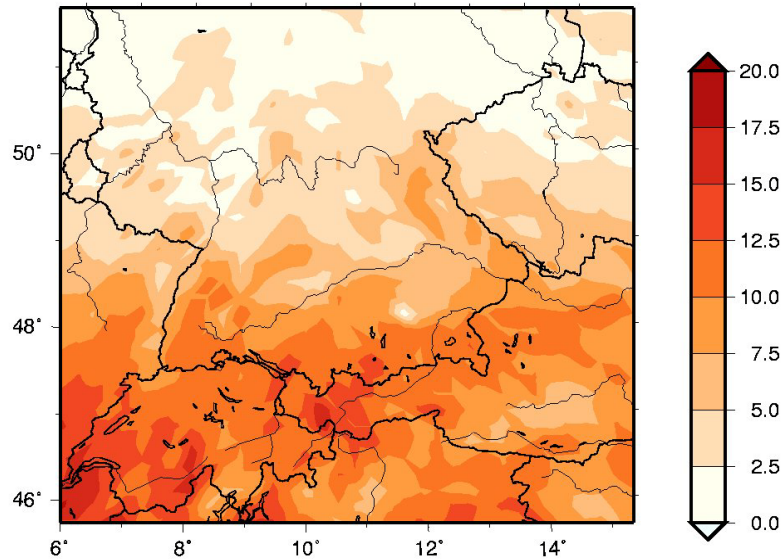


Climate change impact on urban agglomerations

Resolution too coarse for regional impact analysis !

Climate Change Impact

Days with Threshold Exceedance Jun-Aug
Difference 2031/2039 - 1991/2000 uv20



Distribution of daily O₃ maximum

Threshold exceedances in the future

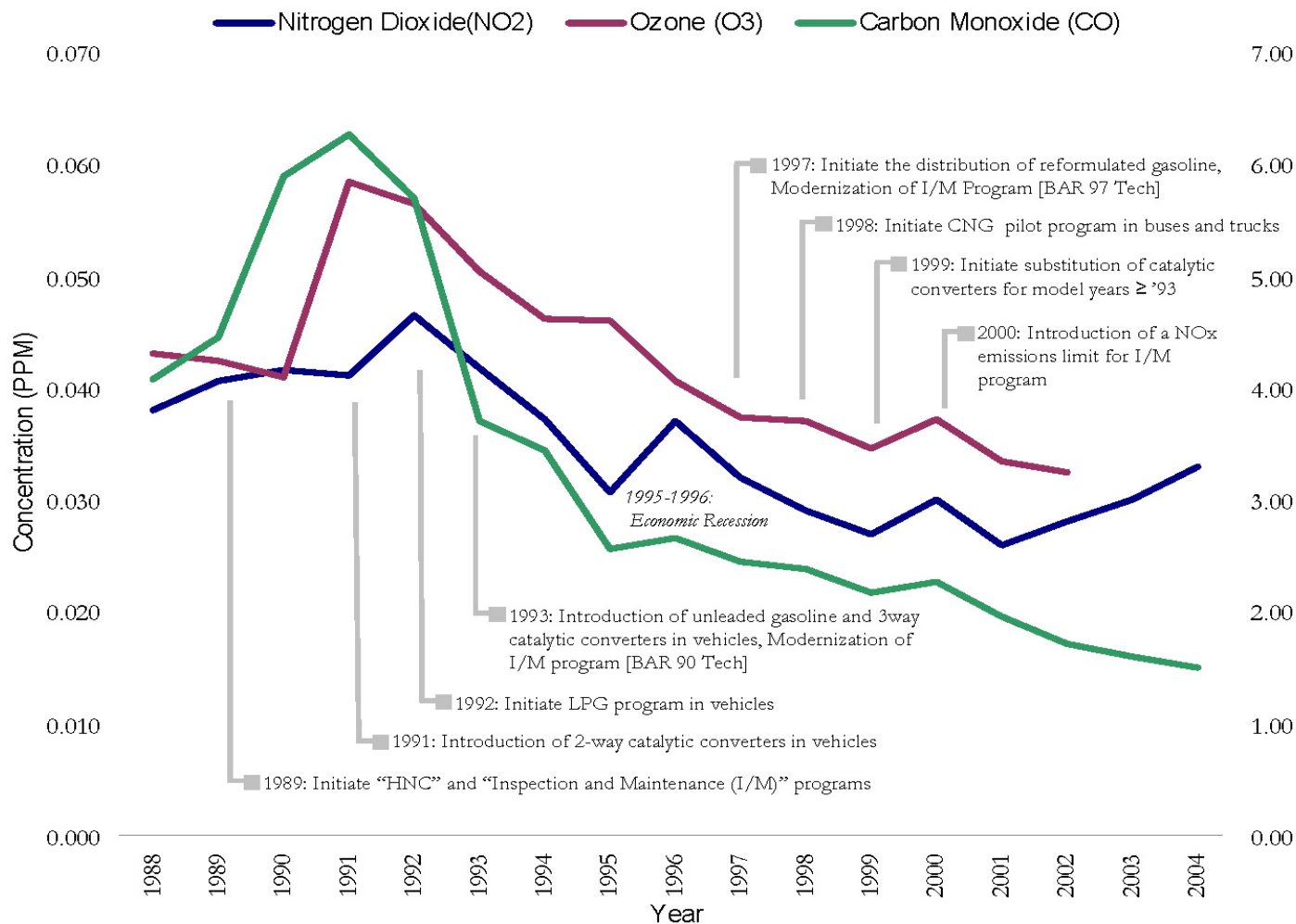
Setup: 60-20 km grid
2x10 years period
Southern Germany

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
- Link between land-use, **energy**, transportation, air quality, **climate change** and health demonstrates the interaction and tackles central problems in a megacity
- To understand the complex system of a megacity, further process studies have to be performed in each discipline
- Air quality and health impact assessment studies are essential prerequisites for mitigation and adaptation strategies
- Tools, technologies and expertise to address these linked issues of air quality and energy supply are available today
- Co-operation has already started

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*”
- **Cooperation** between **Chinese Academy of Sciences (CAS)**, **Chinese Research Academy of Environmental Sciences (CRAES)**, **Chinese Academy of Transportation Sciences (CATS)**, Institute for Epidemiology (EPI) of the **Helmholtz Centre Munich (HMGU)**, Department of Human Exposure Research and Epidemiology of the **Helmholtz Centre for Environmental Research (UFZ)**, and **Karlsruhe Institute of Technology (KIT)** (Institute of Regional Science (IRS), Institute of Mineralogy and Geochemistry (IMG), Institute for Meteorology and Climate Research (**IMK-IFU** Garmisch) on *air quality and health in the Greater Area of Beijing*)



List of measurement systems in Beijing spring 2009

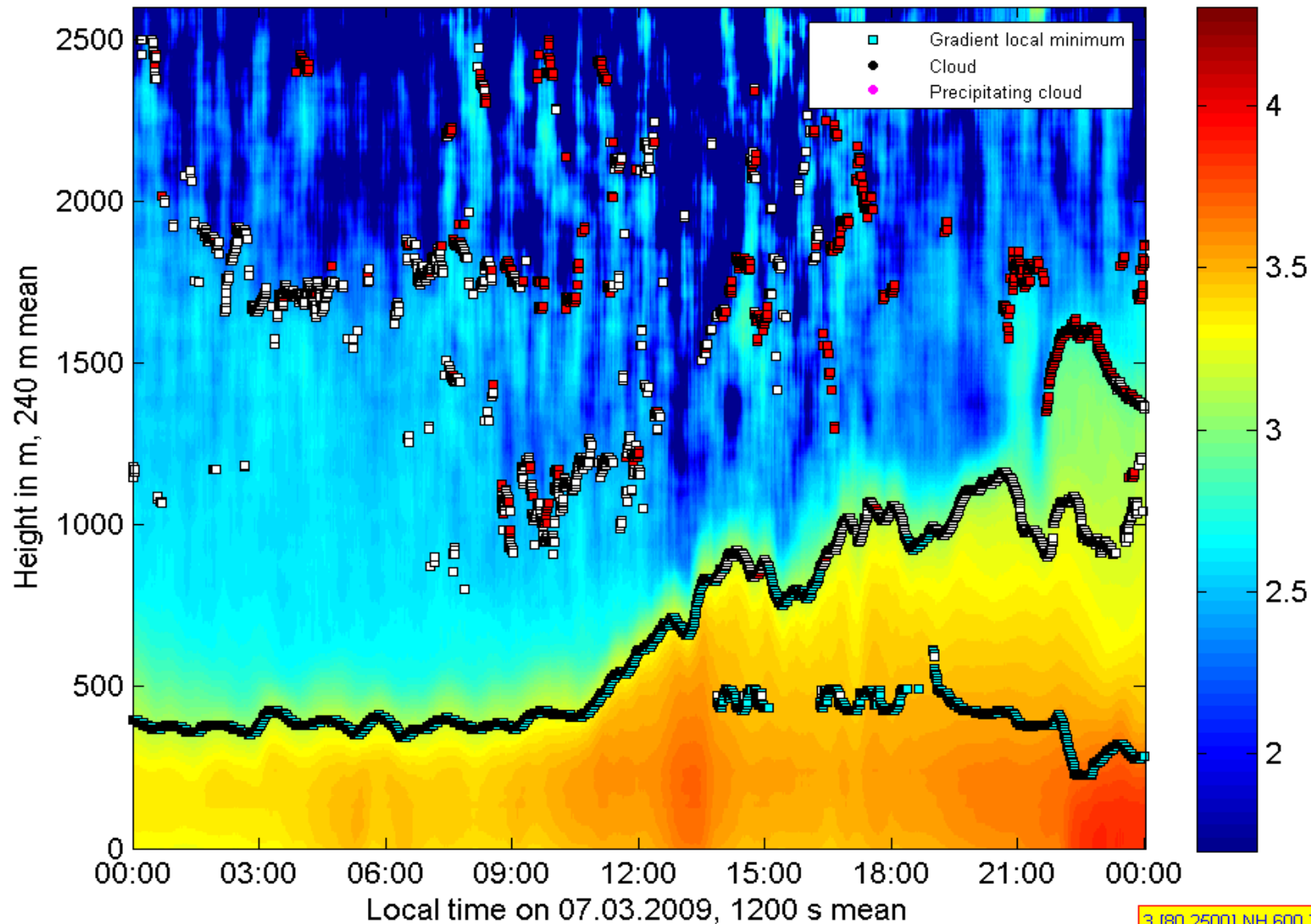
- Layering of the lower atmosphere and mixing layer heights: **ceilometers (IMK-IFU)**, 300 m measurement mast (IAP, IMG, IRS)
- Vertical profile of meteorological data: 300 m mast (IAP)
- Path-averaged concentrations of air pollutants NO, NO₂ (SO₂, O₃, BTX, NH₃, HCHO are possible) near and above the motorway: **DOAS (with three retro-reflectors, up to about 150 m distance to the emitter/receiver-unit, system is changing automatically from path to path) (IMK-IFU)**

Inter-comparisons

Comparison of air pollutant measurements by the DOAS and a monitoring station nearby: NO, NO₂

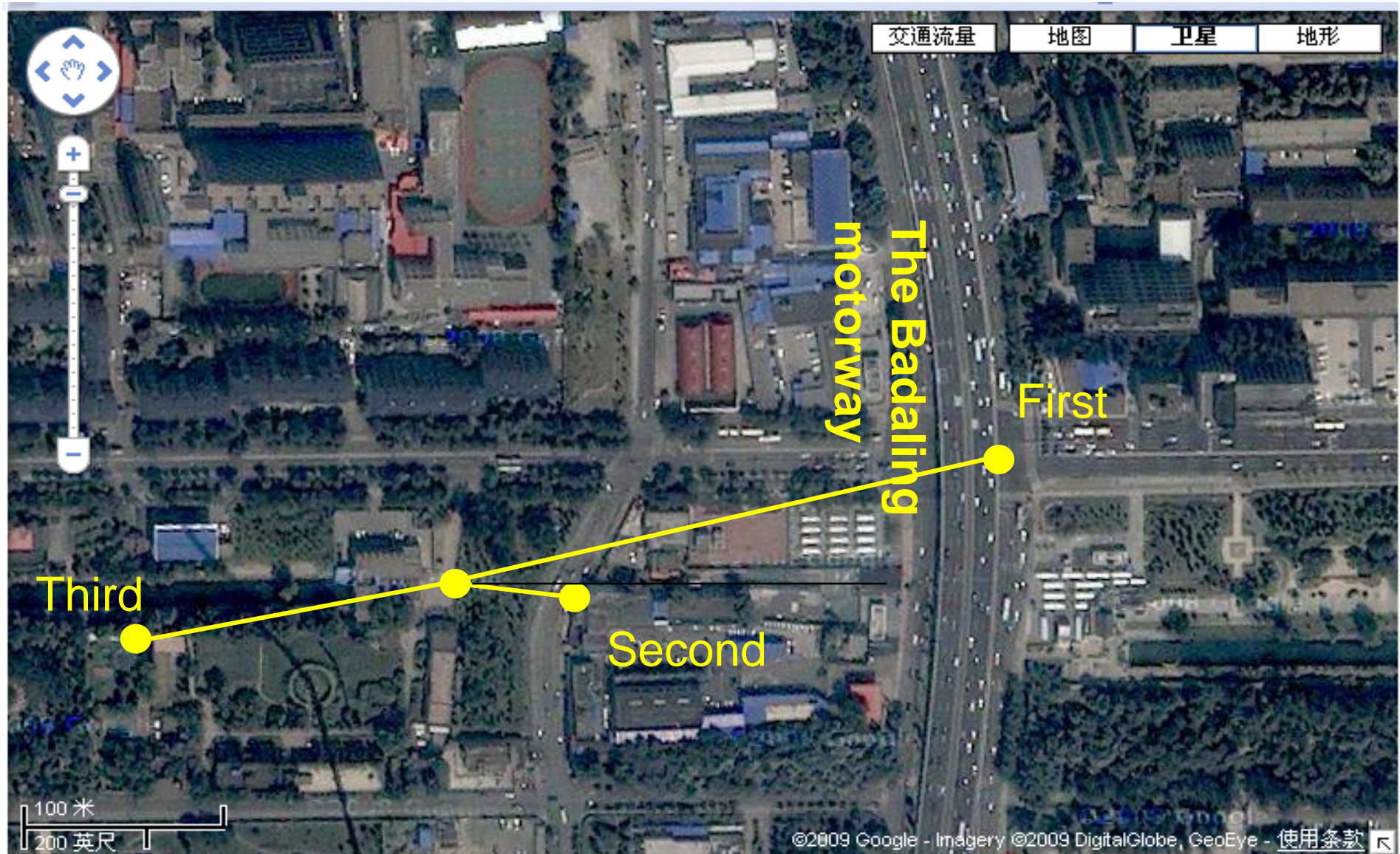
Example: determination of mixing-layer height with a ceilometer, this spring in Beijing

LD40 Beijing \log_{10} of backscatter on 07.03.2009 in $10^{-9} \text{ m}^{-1} \text{ sr}^{-1}$



3 [80 2500] NH 600 TC 0h
MB 300 RG 15% TI 0 HI 80

Near-surface air pollutant monitoring with path-integrating optical methods, DOAS measurement site in Beijing near the 325 m tower



Upcoming event



德国
灵感与创新



Deutschland und China -
Gemeinsam in Bewegung

Deutschland
Land der Ideen



辽宁 / 沈阳

Liáoníng / Shěnyáng

Next station: Liaoning / Shenyang June 12-20, 2009

KIT Topic „Urban Systems“ contributes: „What’s flying in the air? – dust in the atmosphere, from pollen to tire abrasion“ (aerosol pollution in cities). Exposition of microscopes, images, movies, measurement devices, etc.

Thank you very much for your attention

谢谢



