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Air Quality in Cities

A challenge for a sustainable development of urban agglomerations from a different point of view

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Sustainable Development




- **Explorative scenarios**
Early stage investigations
- **Normative scenarios**
Early stage / forced investigations
- **Sensitivity analysis**
Early stage / forced investigations
- **Mitigation & Adaptation**
Forced investigations




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Overview




- **Problems & Impacts**
- **Risk-Habitat-Megacity**
- **Scenario description**
- **Modeling chain**
- **RHM-Results**
- **Urban Heat Island**
- **Conclusions**



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PM₁₀ and Mortality Risk



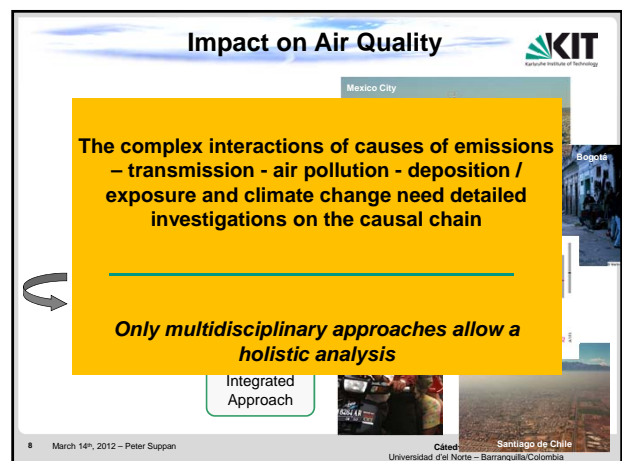
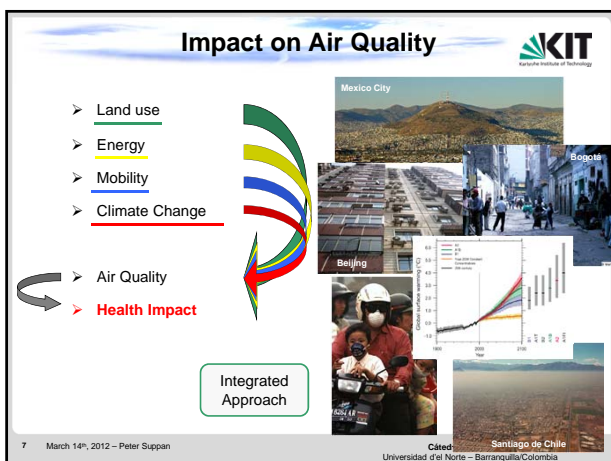
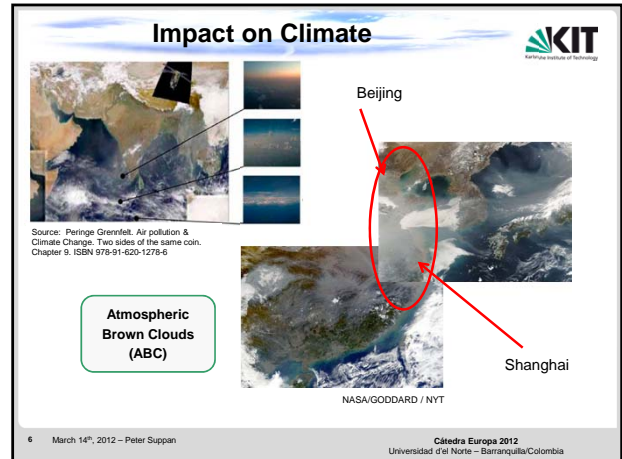
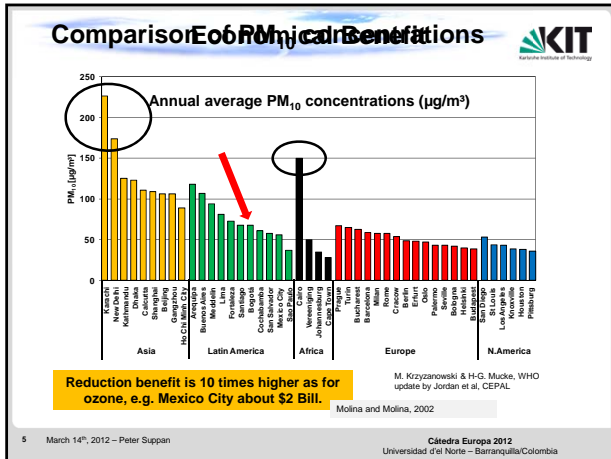
Region	Percentage change	Reference
Asia	4.9% (2.3-7.6)	HEI, 2004
Europe	6.0% (4.0-8.0)	Katsouyanni, 2001
Latin America	6.1% (1.6-10.7)	PAHO, 2005 *
United States	2.1% (0.9-3.3)	Dominici, 2003
Worldwide	6.5% (5.1-7.6)	Stieb, 2002

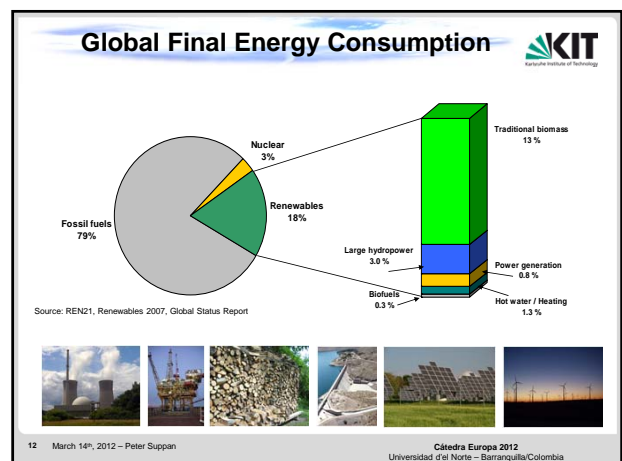
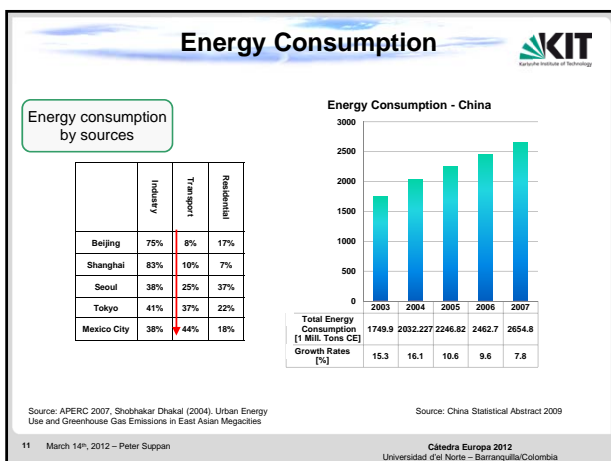
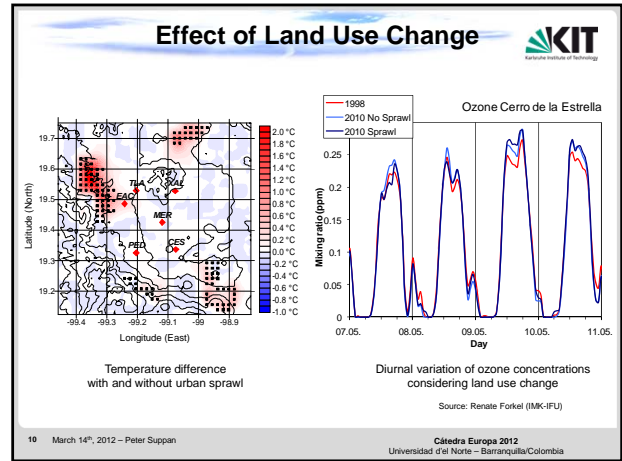
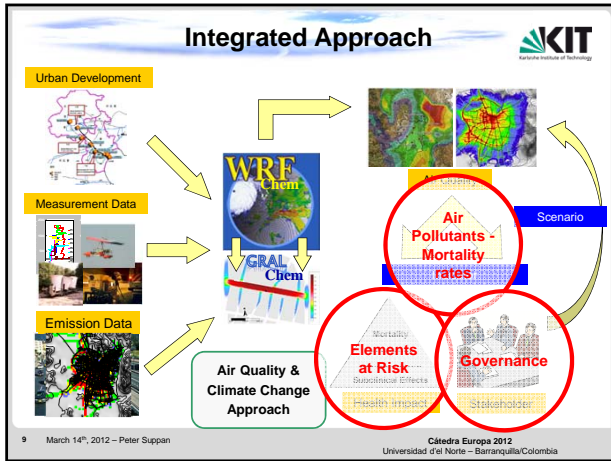
PAN American Health Organization, 2005

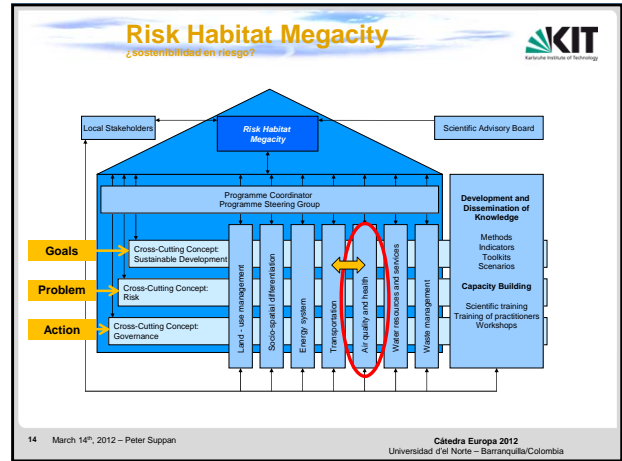
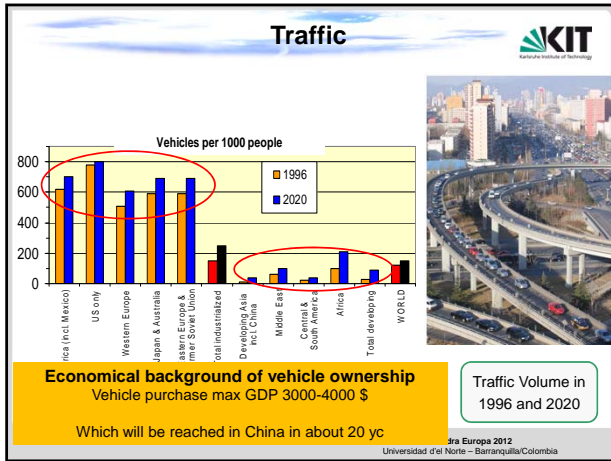
* Based on studies in Mexico City, São Paulo, Santiago de Chile

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Scenarios

Background

- Scenario approach have been discussed with civil society stakeholders and political decision-makers of the regional government and national ministries
- Essential precondition for producing relevant and broadly acceptable project results
- Possible inputs for current planning and decision-making processes in the Santiago Metropolitan Region
- Likewise a necessary precondition for considering longer-term perspectives which are essential in the sustainable development context
- Approach represents an important distinctive feature compared to other projects on Megacity issues

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Framework Scenarios

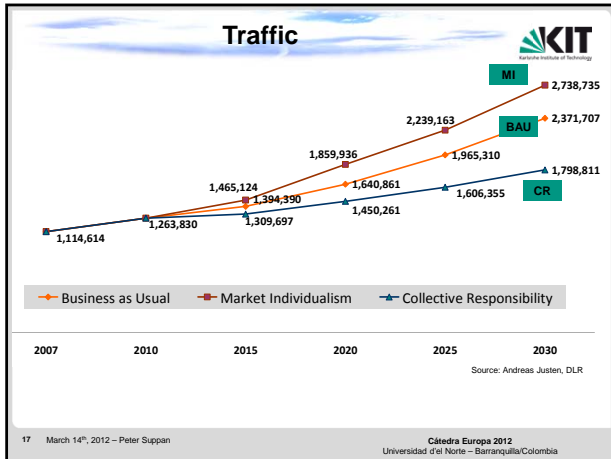
Scenarios based on storylines of societal driving factors (→ until 2030)

- Economic development
- Institutional frameworks
- Demographics
- Technical development
- Societal value system

Business-as-usual (BAU)	Collective Responsibility (CR)	Market Individualism (MI)
Continuation of liberalisation and privatisation trends, persistence of strong market forces and weak public regulation activities, continuation of existing social protection measures and subsidy schemes for the poorest	Characterised by social and environmental justice as principal goals of public regulation, strong regulation of market activities and large public investments, together with the embedding of technologies in society and decoupling of socioeconomic development from resource use	Increasing individual freedom and freedom of action, markets as the dominant vehicle for all societal transactions, together with resources and services generation and distribution strongly subject to supply and demand principles

But also basic socioeconomic variables are estimated:
GDP growth rate, population, household income, persons per household, share of economic branches

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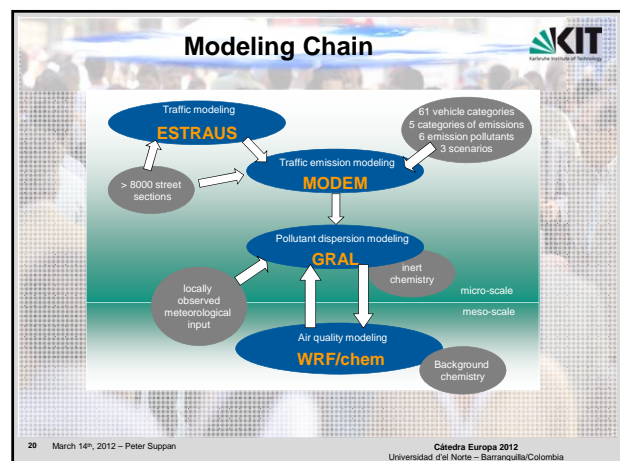


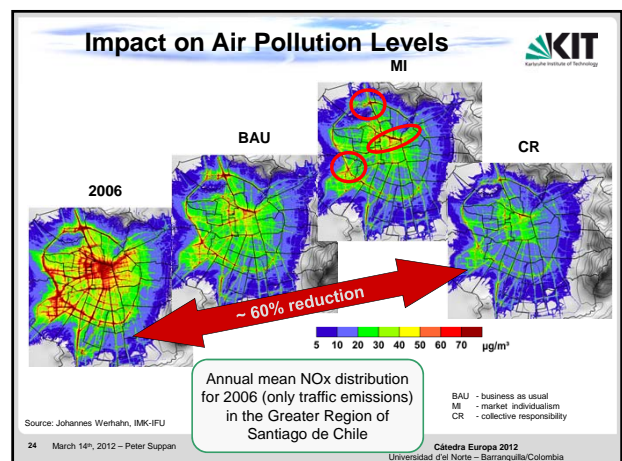
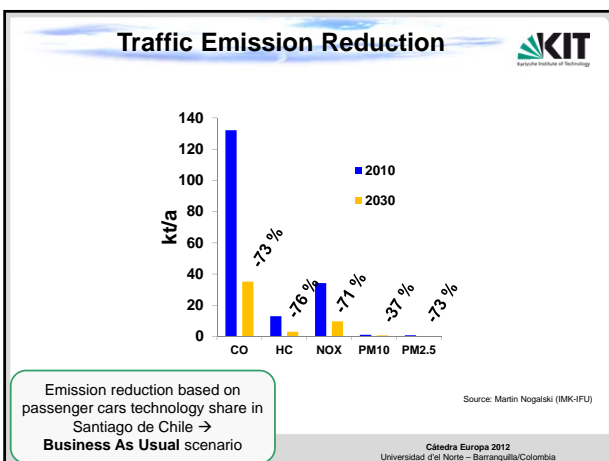
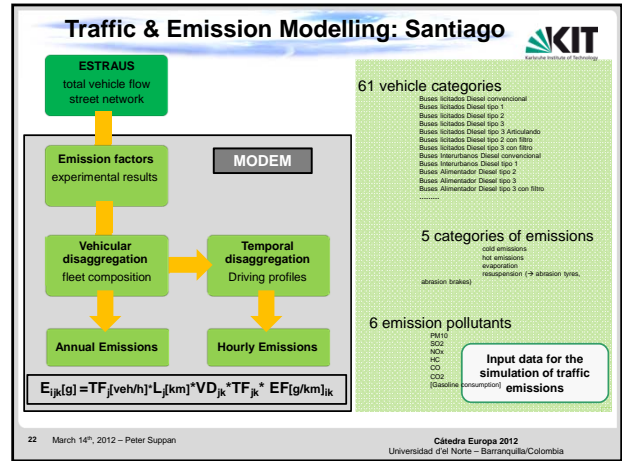
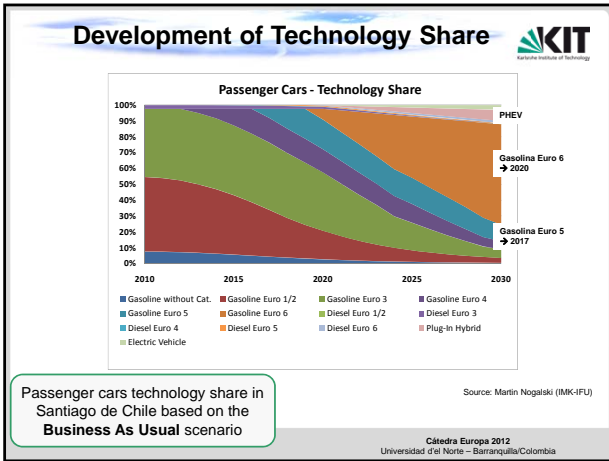
Contextualization of Scenarios

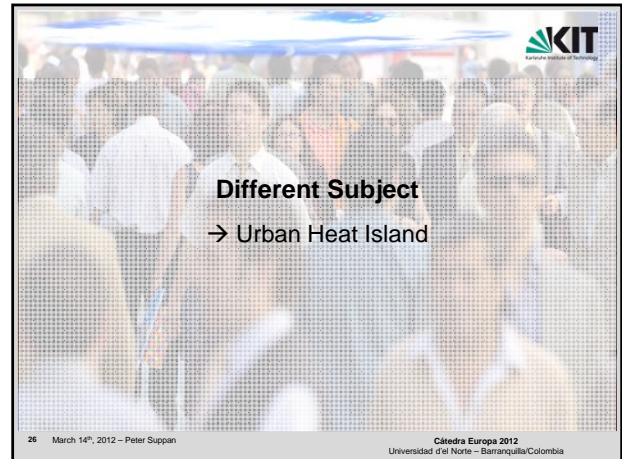
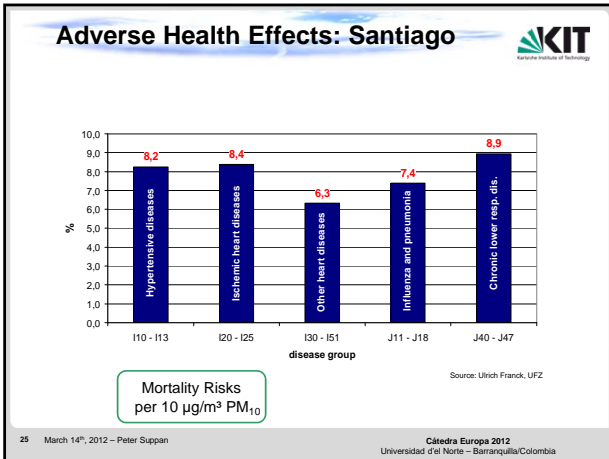
Translation into Transportation / Air Quality & Health

	2010	2030		
		BAU	MI	CR
Modal Split	6.0	7.3	7.5	6.7
Car trips	36.6 %	38.5 %	48.1 %	41.6 %
Bus & Metro trips	49.0 %	45.9 %	35.7 %	43.1 %
Bicycle trips	---	7.0 %	7.0 %	10.0 %
Increase of highways	---	30 %	130 %	0 %
Additional metro lines	---	Line 6	Line 6	Line 6, 3
Transport tariffs	400 CHP	600 CHP	1000 CHP	400 CHP
Emission Standards	EURO3	EURO5: 2017	EURO5: 2018	EURO5: 2015
		EURO6: 2020	EURO6: 2020	EURO6: 2018
		10 % e-propulsion	15 % e-propulsion	15 % e-propulsion

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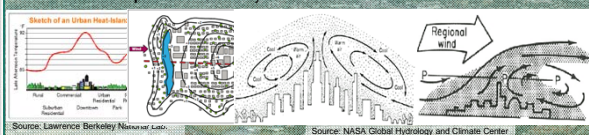






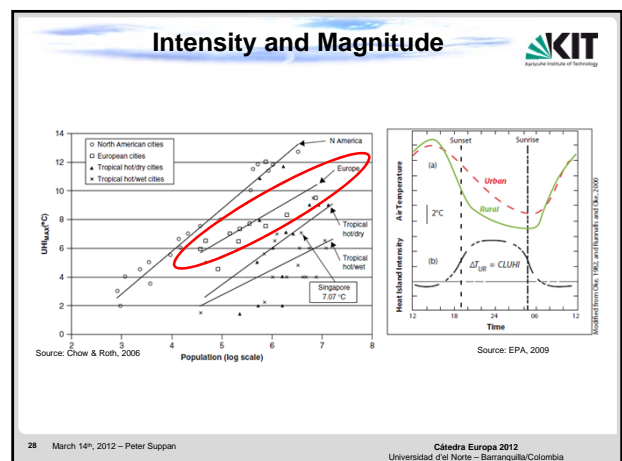
Urban Heat Island

- "Urban Heat Island" (UHI) refers to the tendency for a city or town (urbanized areas) to remain **warmer than its surroundings**.
- The **annual mean temperature** of a large city may be 1°–2°C warmer than the surrounding areas, and on individual calm, clear **nights** may be up to 12°C warmer (→ Heat Island Intensity).
- **Closed isotherms** indicating an area of the surface (→ island) that is relatively warm; most commonly associated areas of human disturbance such as towns and cities (urbanized areas).
- The warmth extends vertically to form an **urban heat dome** in near calm, and an **urban heat plume** in more windy conditions.




Source: Lawrence Berkeley National Lab. Source: NASA Global Hydrology and Climate Center

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Secondary Impacts



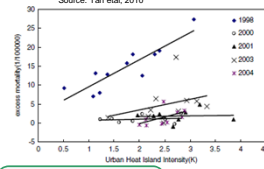
Human Comfort	Winter ↑ Summer ↓	less influence of cold seasons / increase of heat stress
Energy Use	Winter ↑ Summer ↓	less energy consumption / more air conditioning
Air Quality	↓	formation of urban smog / photochemical reactions
Water Use	↓	higher demand of water usage / irrigation
Biological Activity	↑	extension of the growing season
Ice and Snow	↑	less pronounced winter season

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Health Impact

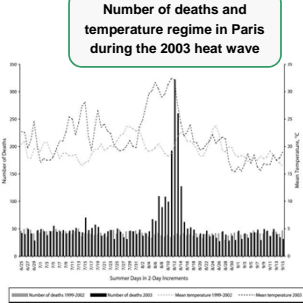


Source: Tan et al, 2010



Mortality rates in Singapore during different heat waves


Number of deaths and temperature regime in Paris during the 2003 heat wave



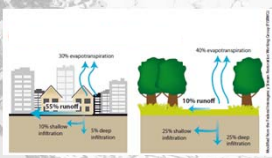

Source: Vandenborren et al. 2004

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Mitigation Measures




- **Increasing albedo**
reflectivity of surfaces / buildings, ...
- **Increasing vegetation cover**
green roofs, parks, avenue trees, ...
- **Decreasing runoff**
open water spaces, ponds, control of impervious surface areas, ...
- **Decreasing anthropogenic heating**
air conditioning, industrial facilities, ...
- **Increasing structural and natural shading**
ancient city structures

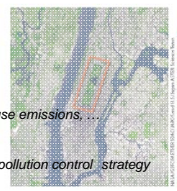



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Benefits




- **on meteorology**
reduction of temperature, wind effects, ...
- **on emissions**
reduction of emissions, aerosols, contribution to green house emissions, ...
- **on air quality**
reactions, photochemistry, regional influence, effective air pollution control strategy
- **on human health**
mortality, morbidity, heat stress, comfort, ...
- **on economy**
health care system, energy consumption (e.g. 100 \$ per air conditioned house), ...



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Conclusions



- Successful sustainable development of cities needs linked knowledge of different disciplines
- Scenario development (mitigation & adaptation) needs multidisciplinary views and approaches
- Traffic modeling & traffic emission modeling and its impact on air quality and health can demonstrate such linkages
- Complex processes can only be described and assessed by multi-scale modeling
- High quality standards are needed not only for the urban level but also for the regional surrounding of cities

„It is now understood that the battle against climate change will likely be won - or lost - in cities.....targeted research at the city level is needed to enable policy makers to understand the magnitude of the impacts (World Bank 2008)

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