Climate Change, Air Quality and Health.
A challenging topic for multidisciplinary research

Klaus Schäfer, Peter Suppan
Overview

- About the Working Group
- Challenges
- Climate Change and Air Quality
- Conclusions
- Outlook
Working Group’s Challenge

Regional Coupling of Ecosystem-Atmosphere Processes, headed by Peter Suppan

- 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)
- Assessment of emission strategies (e.g. source attribution)
Challenges
To understand: Traffic Emissions

**PM$_{10}$**

- Heavy Duty Vehicles (> 16 t konv.): 28.8%
- Heavy Duty Vehicles (7.5-16 t): 9.1%
- Heavy Duty Vehicles (< 7.5 t): 5.8%
- Light Duty Vehicles: 22.1%
- Busses: 12.4%
- Others: 2.8%
- Passenger Cars: 19.0%

Traffic emission distribution for PM$_{10}$ and NO$_x$ in the Greater Region of Santiago de Chile in 2010

**NO$_x$**

- Heavy Duty Vehicles (> 16 t konv.): 27.4%
- Heavy Duty Vehicles (7.5-16 t): 8.2%
- Heavy Duty Vehicles (< 7.5 t): 4.3%
- Light Duty Vehicles: 16.5%
- Busses: 22.9%
- Others: 2.1%
- Passenger Cars: 18.6%
To understand: Biogenic Emissions

- Airchemistry
  - radiation, temperature
  - emission, respiration
  - gas concentrations

- Soil-Biogeochemistry
  - emission, respiration
  - soil temperature
  - nutrient availability
  - litter fall, nutrient uptake
  - water uptake

- Physiology
  - (radiation) temperature
  - water availability
  - water uptake

- Watercycle
  - emission, soil respiration

- Ecosystem-Structure
  - biomass growth
  - allometric relationships
  - root distribution

- Microclimate
  - radiation, temperature
  - shading

Rüdiger Grote, IMK-IFU
To Understand: Biogenic Emissions


Correlation between isoprene flux and diffuse radiation

---

Klaus Schäfer, KIT/IMK-IFU

Workshop on Chemical Processes in the Troposphere
27/11 – 01/12/2011, New Delhi, India
Integrated Approach

Urban Development

Measurement Data

Emission Data

Air Quality & Climate Change Approach

WRF Chem

Air Quality

Scenario

Indicator

Mortality

Subclinical Effects

Health Impact

Stakeholder
Climate Change and Air Quality
Measurement Set Up Beijing

Optical remote sensing: Ceilometer
- Wave length: 855 or 910 nm
- Range: 4000 m
- Resolution: 10 or 7.5 m

Optical remote sensing: DOAS –
- NO$_2$, NO, O$_3$, SO$_2$, NH$_3$, HCHO, BTX

In situ: NO$_x$, CO, O$_3$, SO$_2$, PM$_{2.5}$ on 8 m and PM$_{2.5}$ on 80 m altitude at 325 m LAPC tower
Mixing layer height - air quality

If planetary boundary layer > 1000 m: often multiple layering  
if < 1000 m during daytime: often one layer

Influence of MLH upon NO$_2$: relevant – standard error 0.15

Correlations of NO and SO$_2$ with MLH: not significant

Concentrations of NH$_3$, BTX and HCHO: near the detection limit

High PM$_{2.5}$ load (40 – 140 µg/m$^3$) near the surface is coupled with  
MLH if much lower than 1000 m
Daily PM$_{2.5}$ filter (150 mm ø Quartz fibre) samples with 2 High-volume samplers from 21 June 2010 on for one year

Ultra-sonic anemometer

10 m distance to instrumentation of DWD and KIT / Institute of Mineralogy and Geochemistry (IMG)

Klaus Schäfer, Rongrong Shen, IMK-IFU & CUMTB & CUGB

Wind Variation for Beijing

Whole year

Summer 2010

Autumn 2010

Winter 2010

Spring 2011

Summer 2011

Original data of ZBAA

Rongrong Shen & Klaus Schäfer, IMK-IFU
Mixing layer height - air quality

Influence of MLH upon element mass concentrations is significant if origin of elements is

- a widespread area source (Cu, Zn)
- traffic and industry (Pb, As, S, Cd) – air transport important also

No MLH influence: if soil source dominates (Ti, Al and Ca),
Satellite images (Landsat)
100 km x 100 km, 30 m x 30 m
520 nm: PM size 0.2 - 1.0 µm
• reference - clear atmosphere
• polluted situation
• AOD

Ground-based measurements
• Aerosol mass extinction efficiency \( \beta_{\text{ext}} = \frac{\text{AOD}}{\text{MLH}} = a\text{PM} \)
  a: AOD – sun photometer, PM – in situ
• MLH - ceilometer

Simulations / Measurements

Air Quality Modeling (MCCM-MM5/CAMx-WRF/chem)

Renate Forkel, Guiqian Tang & Klaus Schäfer, IMK-IFU & IAP

Mixing layer height (Ceilometer at IAP)

Simulation of dust storm event with meso-scale model

Setup: Northern China
28 x 28 km grid
2006, April 3\textsuperscript{th} - 12\textsuperscript{th}

Near surface dust concentrations on April 8\textsuperscript{th}, 23h UTC

Comparison with temperature and relative humidity measurements

Stefanie Schrader & Klaus Schäfer, IMK-IFU
Micro-Scale Air Pollution Distribution

Annual mean $\text{NO}_x$ on distribution for 2006 and different scenarios within the Greater Region of Santiago de Chile


- BAU - business as usual
- MI - market individualism
- CR - collective responsibility

Johannes Werhahn, IMK-IFU
Regional Climate Change Impact

Ozone threshold exceedances in the future

Distribution of daily $O_3$ maximum

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

Conclusions

- Linkage between air quality & climate change highly complex
- Only holistic and multidisciplinary approaches can help to get a deeper knowledge
- We have to investigate in
  - Knowledge about traffic emissions and its development
  - Feedback mechanisms climate change & air quality
  - Consequences to human health
- Only this understanding allows investigations in future developments and recommendations for decision makers and stakeholders to improve air quality and to limit climate change
Outlook

- Regional Climate Change Impact: high resolution climate-chemistry simulations, as done for a 10-years variation in Mexico City

- Aerosol Feedback Mechanisms: temperature, humidity and precipitation change

**About MICMoR**

The public interest in climate change research is large, whether it be receding glaciers, heat waves or a flood of the century. Especially mountain regions are sensitive to climate change, however, the understanding of its processes is still limited. The newly established MICMoR Research School at KIT/IMK-IFU in Garmisch-Partenkirchen is a graduate programme to prepare PhD students for navigating in the highly interdisciplinary and complex field of climate change research in mountain regions.

MICMoR’s research focuses on the interfaces of Atmosphere-, Biosphere- and Pedo-/Hydrosphere-disciplines and studies the impact of a changing climate on 1. energy & greenhouse gas fluxes, 2. water cycle, 3. biodiversity & ecosystem functioning. The methods reach from empirical to modelling approaches and Remote Sensing techniques; research is conducted at the TERENO pre-Alpine Observatory. MICMoR’s vision is to foster comprehensive interdisciplinary approaches and improving knowledge of processes influenced by climate change.

To become a part of an interdisciplinary graduate training programme and a member of a highly inspiring Climate Change Network, we welcome all interested PhD candidates to apply for a MICMoR fellowship.

**MICMoR Fellowships**

MICMoR offers supplemental funding for PhD students enrolled in a PhD programme at their home university. The Fellowship entails:

- Fully supported participation in scientific & professional training programme in climate change disciplines.
- A top-level research environment & infrastructure at IMK-IFU and partner institutions e.g. TERENO pre-Alpine Observatory.
- Sponsorship of conference participation and research visits in labs abroad.
- Intensive mentoring through a Thesis Advisory Committee with regular meetings and a structured research plan.
- Stimulating work within a Climate-Change network and exchange with international experts.

**Home Institute & Partners**

The Karlsruhe Institute of Technology (KIT) will host MICMoR at its Institute of Meteorology & Climate Research / Atmospheric Environmental Research (IMK-IFU) in Garmisch-Partenkirchen. Partners are TUM and LMU (Munich), the Universities of Augsburg, Bayreuth and Würzburg, DLR and Helmholtz Center Munich.

**MICMoR’s Graduate Programme**

The PhD Programme comprises research training, professional preparation, networking with other fellows, mentors and international experts in the climate change field, participation at conferences and research visits abroad.

**Summer Schools:**

Broad knowledge of Atmosphere-Biosphere-Pedo-/Hydrosphere Essentials, i.e.

1. Climate-Earth System Science,
2. Observation and Experimental Methods,
3. Process and Regional Modelling

**Technical Short Courses:**

- In-depth specialization & methodic skills;
- Topics adapted to Fellows’ needs.

**Transferable Skills Courses:**

- Professional preparation (e.g. Scientific Writing, Leadership Skills).

**Research Forum:**

Exchange within the MICMoR Community.

**Research visits and conferences:**

- Exchange with international experts.

**„Spitzenforscher-Werkstatt“:**

Workshop with top scientists and MICMoR Fellows at Schneefernerhaus / Mount Zugspitze.
Thank you very much for your attention

Cooperation Partners

Bhola R. Gurjar
Stefan Norra
Yuesi Wang, Guiqian Tang, Xin Jinyuan
Longyi Shao
Kuang Cen
Jose Agustín García, Gerardo Ruiz
Rainer Schmitz, Ricardo Muñoz
Barbara Lenz, Andreas Justen
Ulrich Franck
Annette Peters, Alexandra Schneider
Johannes Rehner, Ricardo Jordán

Indian Institute of Technology (IIT), Department of Civil Engineering, Roorkee, India
Institute of Mineralogy and Geochemistry (IMG), Karlsruhe Institute of Technology (KIT)
Chinese Academy of Sciences (CAS), Institute of Atmospheric Physics (IAP), Beijing
Chinese University of Mining and Technology (CUMTB), Beijing
Chinese University of Geosciences (CUG), Beijing
Universidad Nacional Autonoma de Mexico (UNAM), Mexico City
Universidad de Chile (UdC), Santiago de Chile
German Aerospace Center (DLR), Berlin, Germany
Helmholtz Zentrum für Umweltforschung (UFZ), Leipzig, Germany
Helmholtz Zentrum München (HMGU), Institute for Epidemiology, Munich, Germany
Economic Commission for Latin America and the Caribbean (ECLAC/CEPAL) in the UN