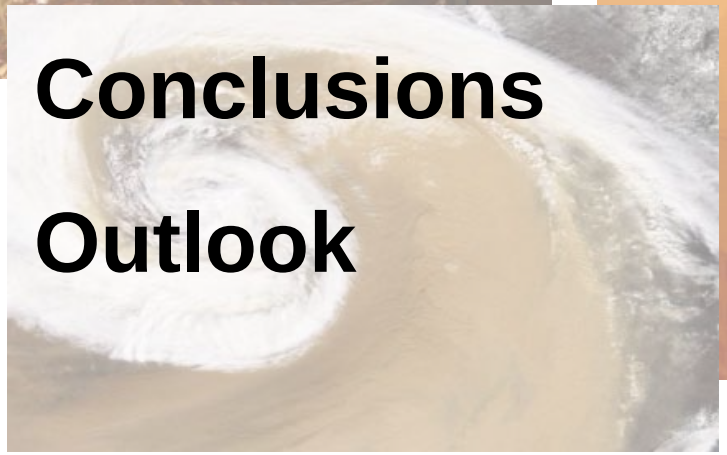
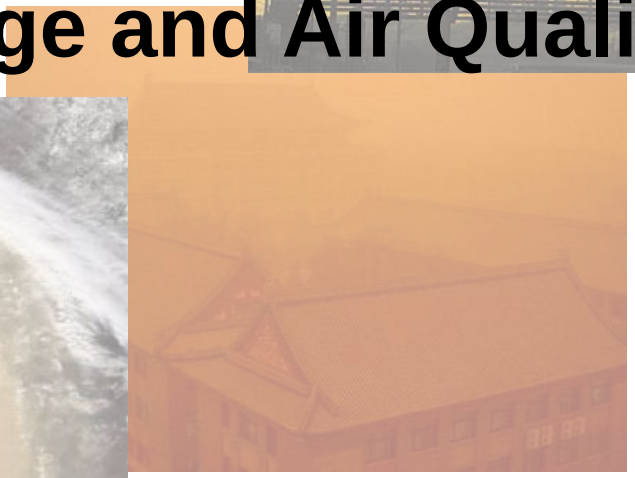
Climate Change, Air Quality and Health.
A challenging topic for multidisciplinary research

Klaus Schäfer, Peter Suppan

Institute for Meteorology and Climate Research (IMK-IFU), Karlsruhe Institute of Technology (KIT), Campus Alpine, Germany

Overview





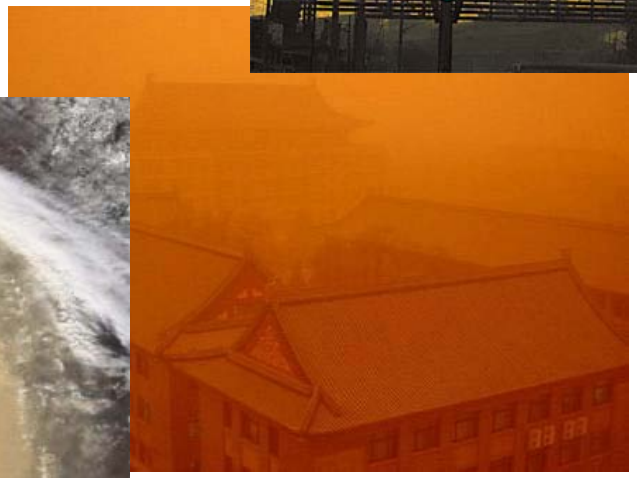
- About the Working Group
- Challenges
- Climate Change and Air Quality
- Conclusions
- Outlook

Working Group's Challenge

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

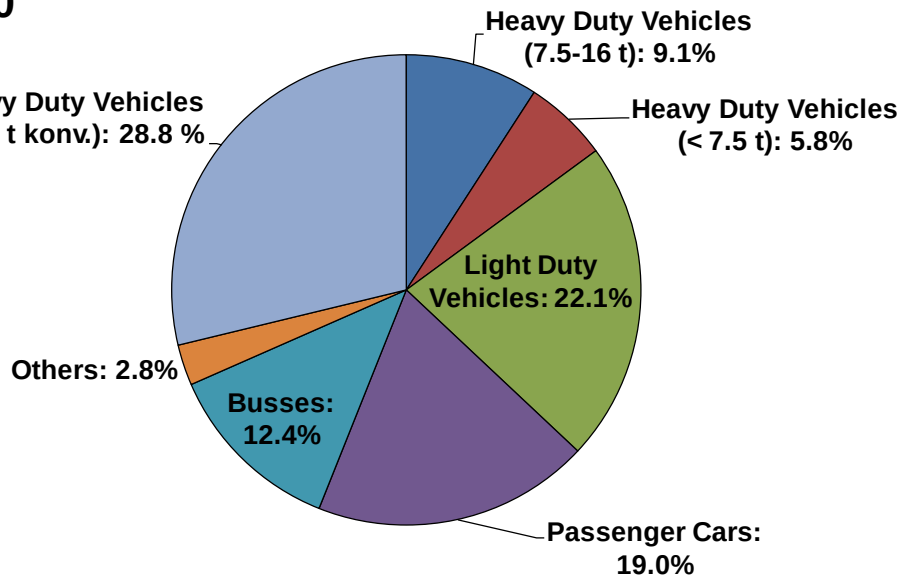
- Interactions between urban/suburban/rural regions and their feedback mechanism to the air quality
- Impact of regional climate change on air quality
- Developing and validation of innovative measuring techniques for the assessment of the air quality (e.g. urban agglomerations – close cooperation with epidemiologists)
- Coupling of models (e.g. MCCM, WRF/Chem, micro-scale models)
- Assessment of emission strategies (e.g. source attribution)

Challenges

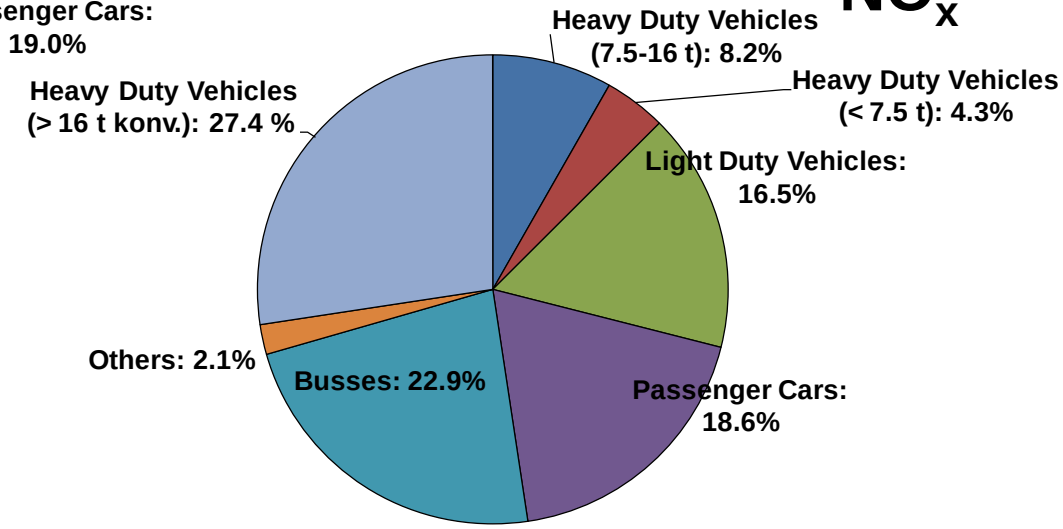


To understand: Traffic Emissions

PM_{10}

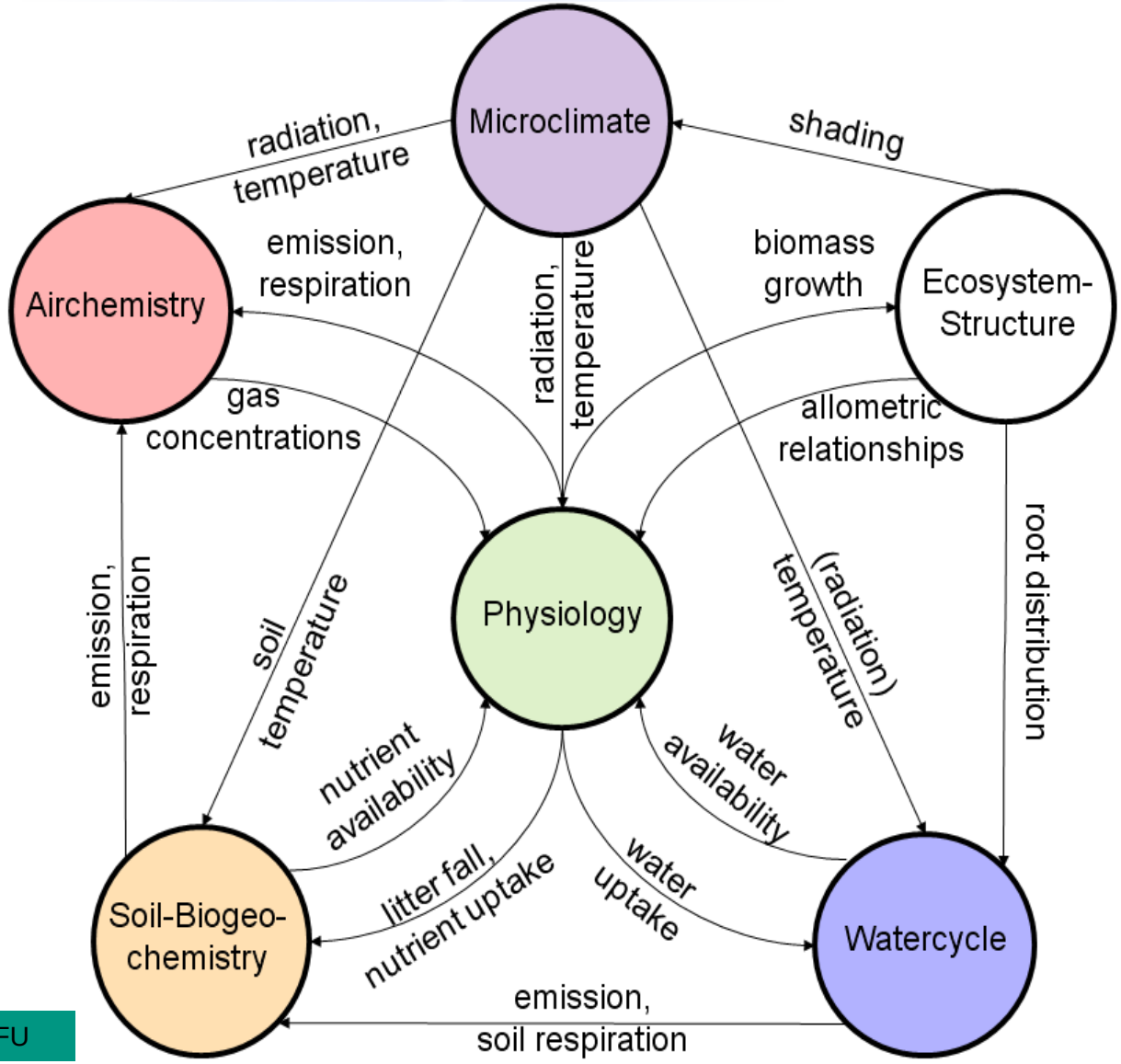


NO_x



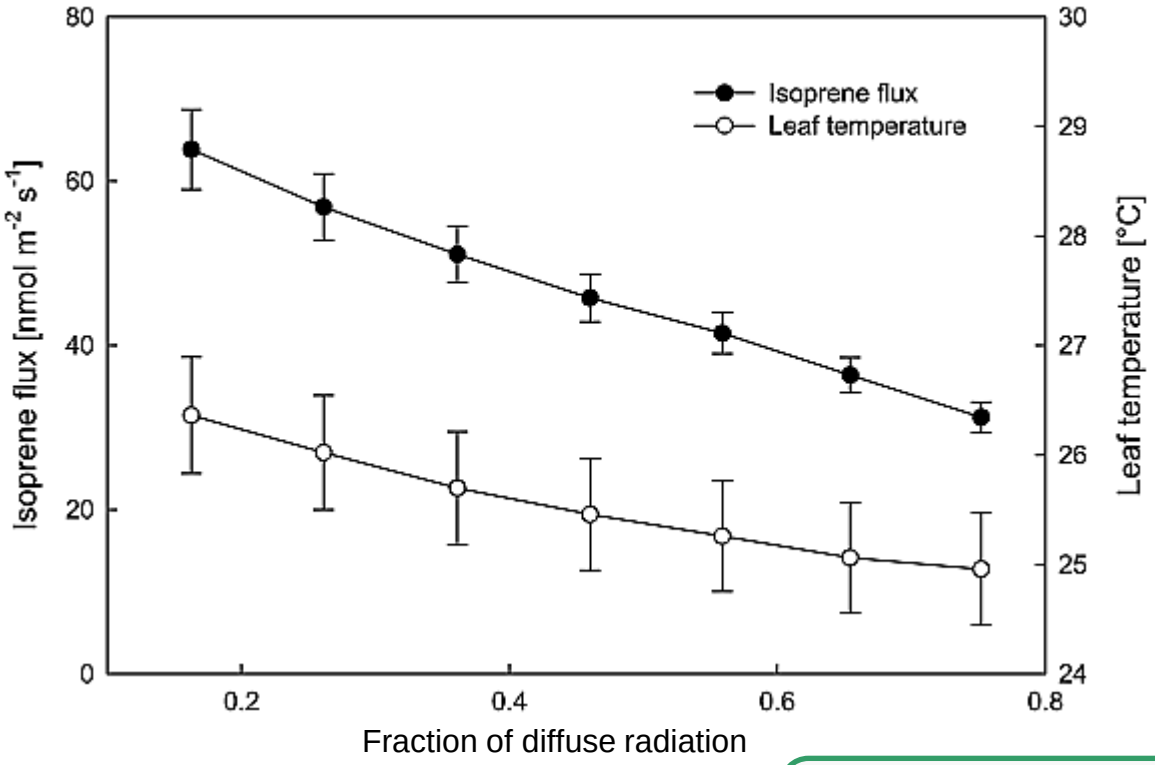
Traffic emission distribution for PM_{10} and NO_x in the Greater Region of Santiago de Chile in 2010

To understand: Biogenic Emissions



Rüdiger Grote, IMK-IFU

To Understand: Biogenic Emissions



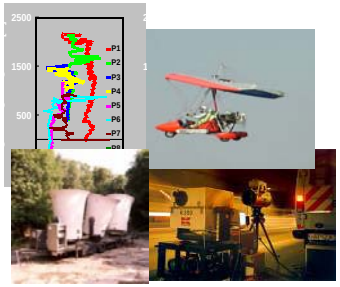
Correlation between isoprene flux and diffuse radiation

Knohl & Baldocchi (2008): Effects of diffuse radiation on canopy gas exchange processes in a forest ecosystem, Journal of Geophysical Research, Vol. 113

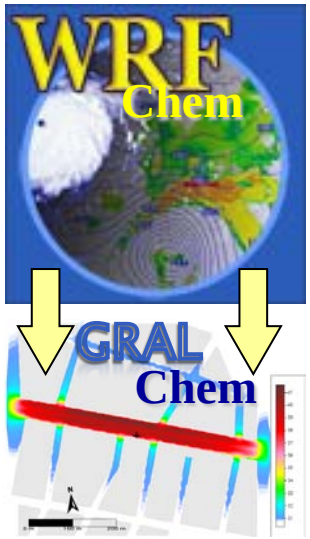
Integrated Approach

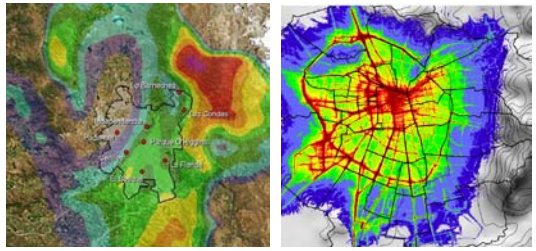
Urban Development

Measurement Data



Emission Data





Air Quality

Scenario

Indicator

Mortality

.....

.....

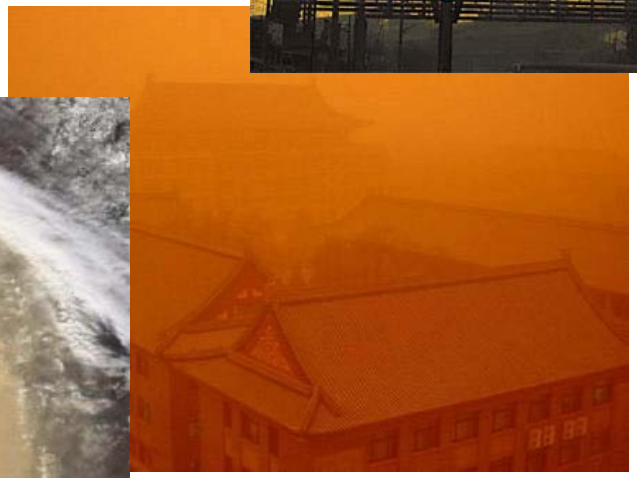
Subclinical Effects

Health Impact

Stakeholder

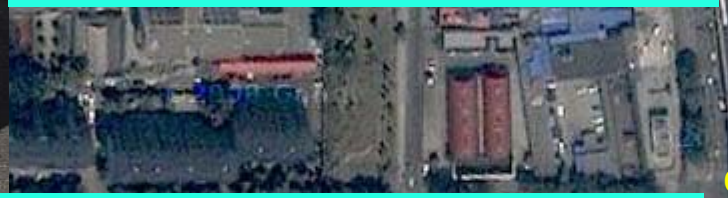
Air Quality & Climate Change Approach

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

Third

First

Second

The Badaling motorway

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

Hong Ling & Klaus Schäfer, IMK-IFU & IAP

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

Klaus Schäfer, IMK-IFU

Measurement Set Up Beijing

Daily $PM_{2.5}$ filter (150 mm ø Quartz fibre) samples with 2 High-volume samplers from 21 June 2010 on for one year

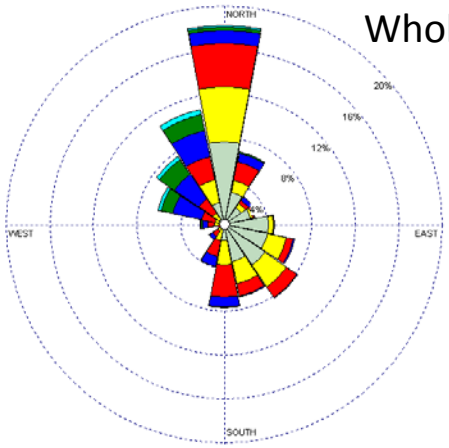
Ultra-sonic anemometer

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

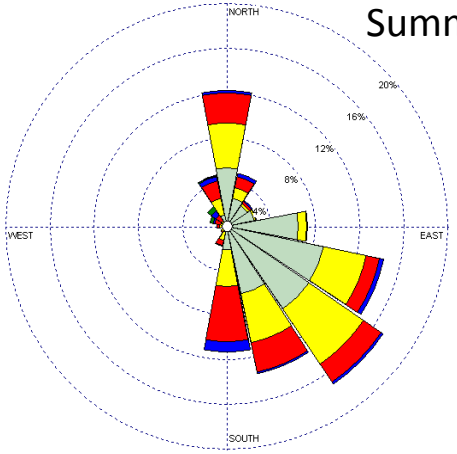
Klaus Schäfer, Rongrong Shen, IMK-IFU & CUMTB & CUGB

SCHNELLE-KREIS, J.; ORASCHE, J.; ABBASZADE, G.; SCHÄFER, K.; HARLOS, D.P.; HANSEN, A.D.A.; ZIMMERMANN, R.: Application of direct thermal desorption gas chromatography time-of-flight mass spectrometry for determination of non-polar organics in low volume samples from ambient particulate matter and personal samplers. Anal Bioanal Chem 401, 3083–3094 (2011); DOI 10.1007/s00216-011-5429-x.

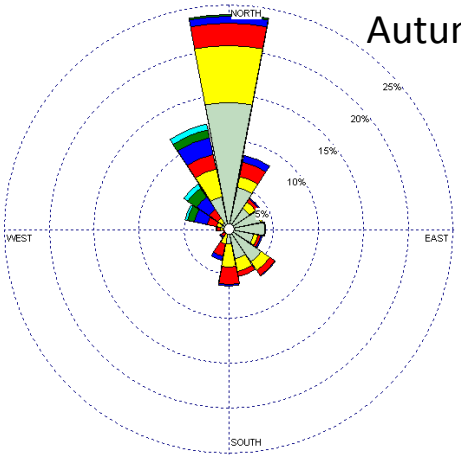
Wind Variation for Beijing



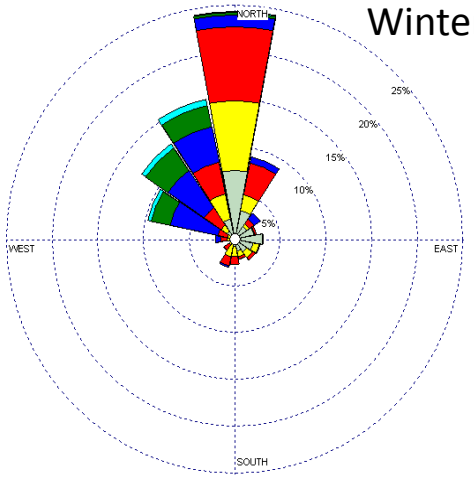
Whole year



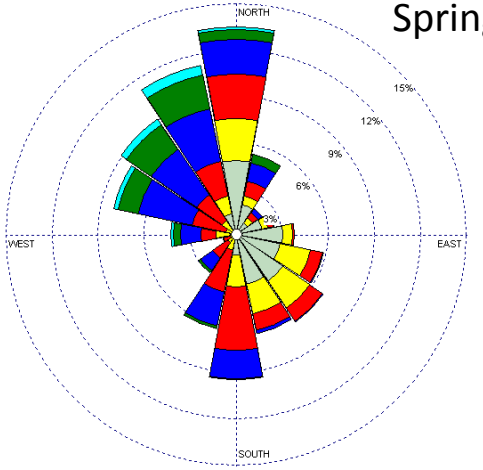
Summer 2010



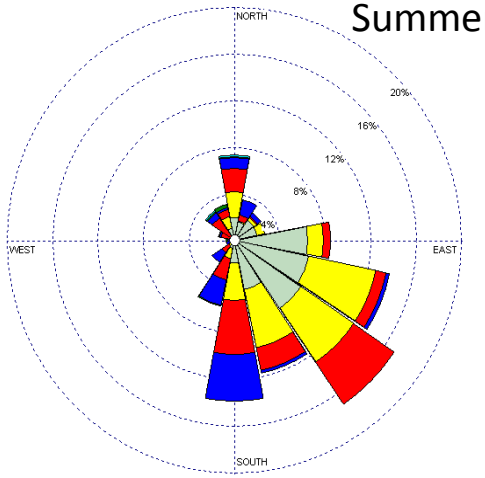
Autumn 2010



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),

Klaus Schäfer, IMK-IFU

Integrated Platform - ICAROS

Satellite images (Landsat)

100 km x 100 km, 30 m x 30 m

520 nm: PM size 0.2 - 1.0 µm

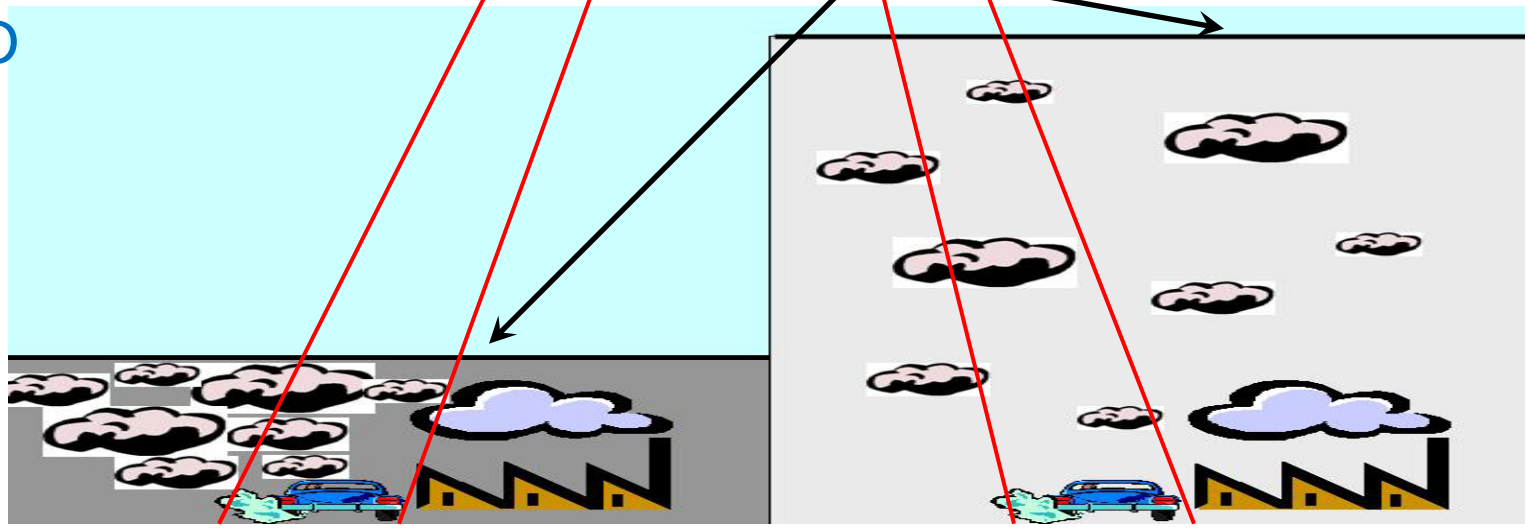
- reference - clear atmosphere
- polluted situation
- AOD

Ground-based measurements

- Aerosol mass extinction efficiency β_{ext}=AOD/MLH=aPM

  a: AOD – sun photometer,
  PM – in situ

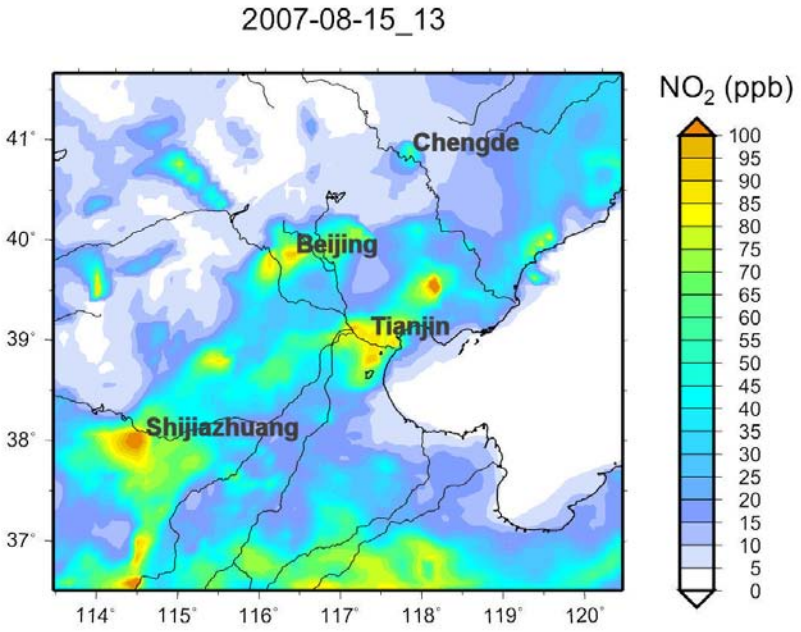
- MLH - ceilometer

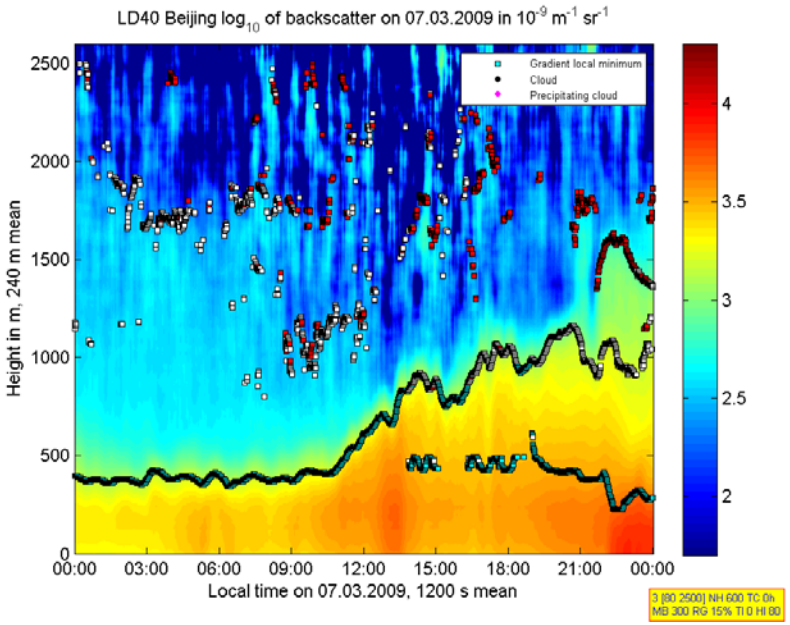


Schäfer, K., Harbusch, A., Emeis, S., Koepke, P., Wiegner, M.: Correlation of aerosol mass near the ground with aerosol optical depth during two seasons in Munich. Atmospheric Environment, 42, 18, 4036-4046 (2008); DOI: 10.1016/j.atmosenv.2008.01.060.

Stefanie Schrader & Klaus Schäfer, IMK-IFU

Simulations / Measurements





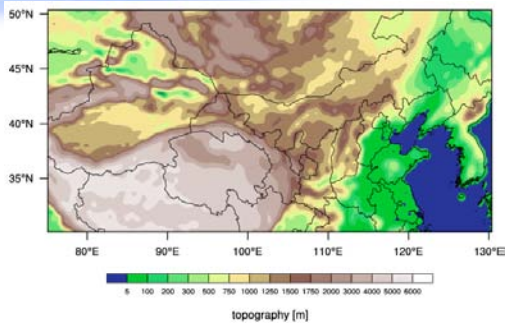
Air Quality Modeling (MCCM-MM5/CAMx-WRF/chem)

Mixing layer height (Ceilometer at IAP)

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

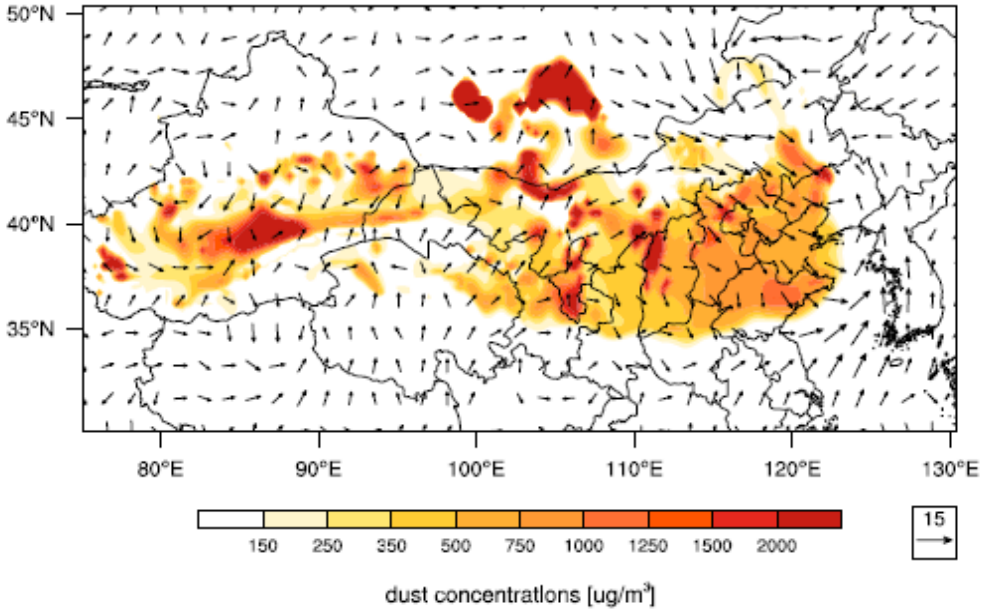
Schäfer, K., Emeis, S., Hoffmann, H., Jahn, C.: Influence of mixing layer height upon air pollution in urban and sub-urban area. Meteorol. Z. 15 (2006), 647-658, DOI: 10.1127/0941-2948/2006/0164.

Simulation of dust storm event with meso-scale model

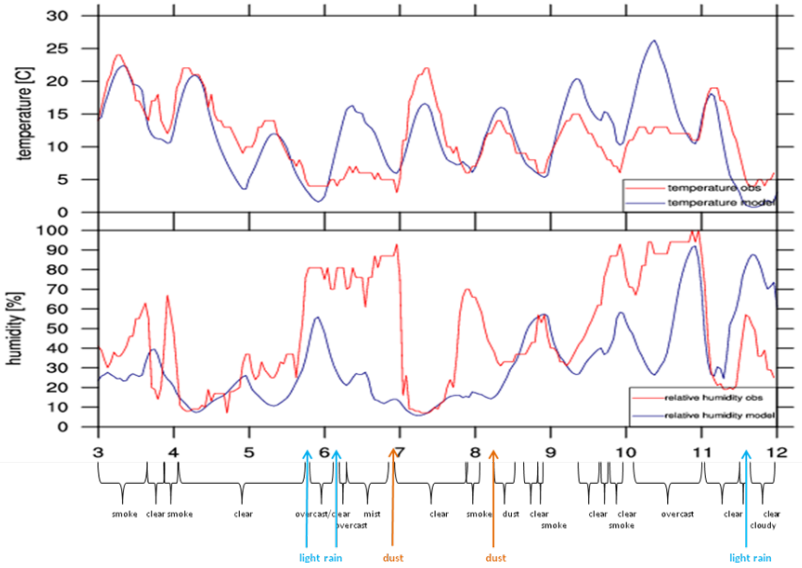


Setup: Northern China
28 x 28 km grid
2006, April 3th - 12th

Near surface dust concentrations on April 8th, 23h UTC

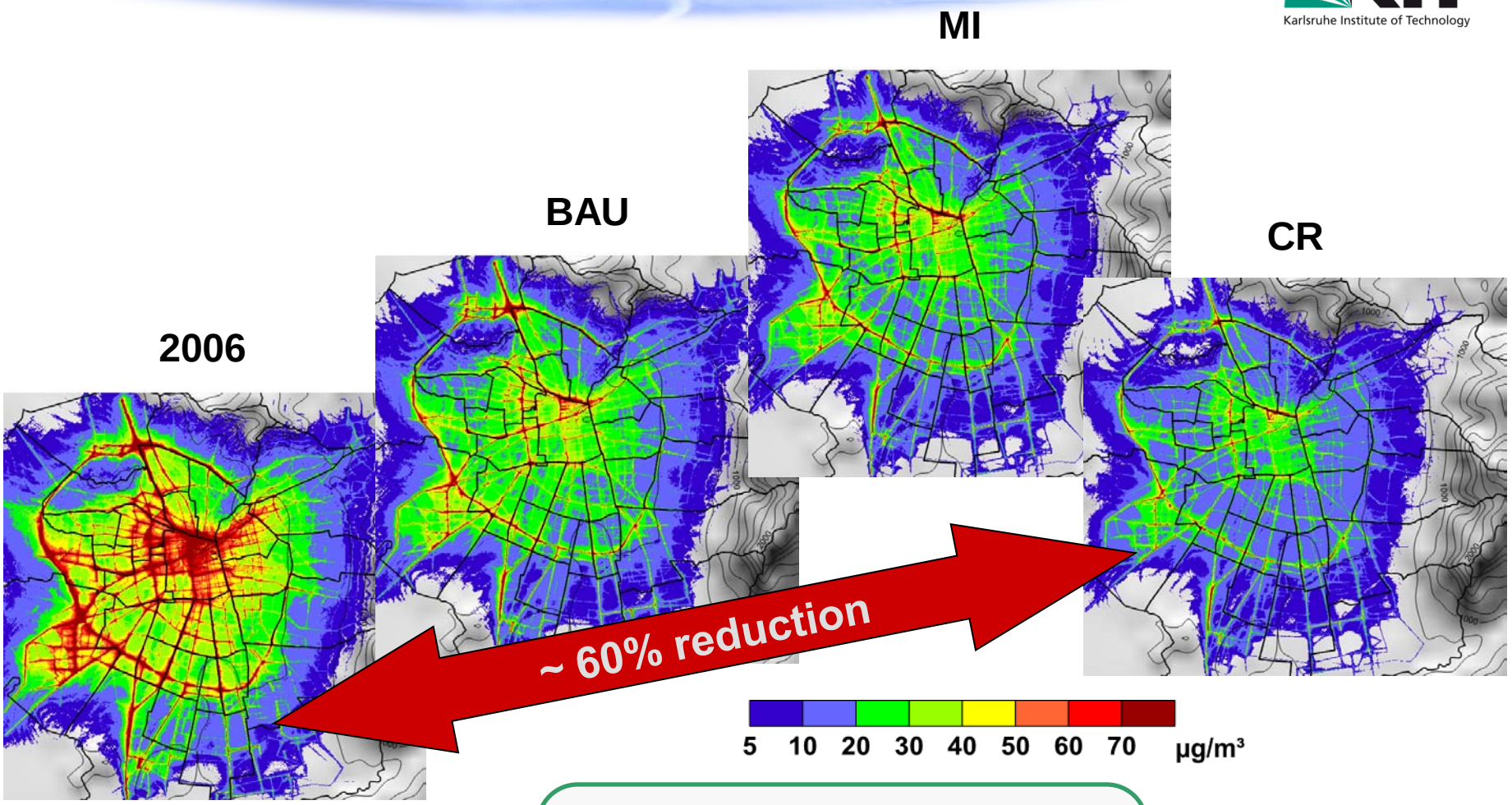


Comparison with temperature and relative humidity measurements



Stefanie Schrader & Klaus Schäfer, IMK-IFU

Micro-Scale Air Pollution Distribution



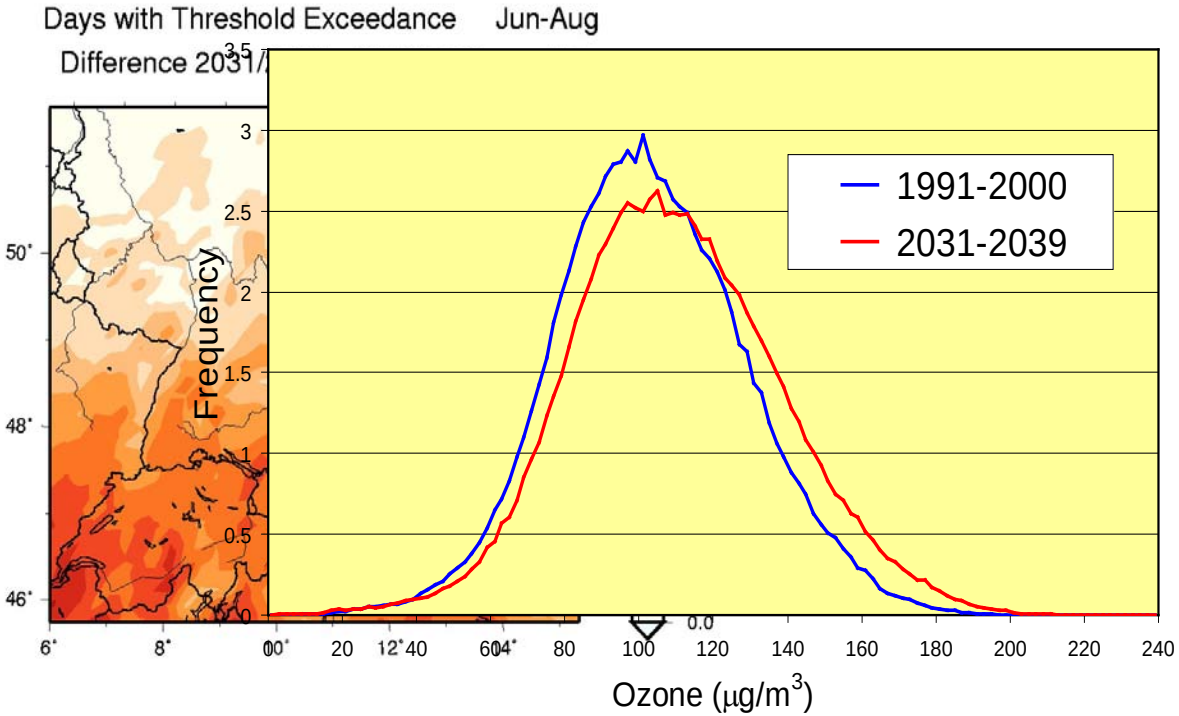
Suppan, P., Franck, U., Schmitz, R., Baier, F., 2011: Air Quality and Health: A Hazardous Combination of Environmental Risks. In: Heinrichs, D.; Hansjürgens, B. und Krellenberg, K. (eds.): Risk Habitat Megacity, Springer Verlag. Berlin, Heidelberg (in press)

Annual mean 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

Forkel, R., & Knoche, R., 2006: Regional climate change and its impacts on photooxidant concentrations in southern Germany: Simulations with a coupled regional climate-chemistry model, J. Geophys. Res., 111, No.D12,D12302, doi:10.1029/2005JD006748 (13pp.)

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

Renate Forkel, IMK-IFU

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

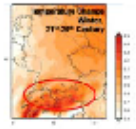
- Regional Climate Change Impact: high resolution climate-chemistry simulations, as done for a 10-years variation in Mexico City

- Aerosol Feedback Mechanisms: temperature, humidity and precipitation change

Forkel, R., etal., 2012: Effect of aerosol-radiation feedback on regional air quality - A case study with WRF/Chem. Atmospheric Environment, 45, doi:10.1016/j.atmosenv. 2011.10.009 (special issue about the AQMEII initiative)

Karlsruhe Institute of Technology

MICMoR Mechanisms and Interactions of Climate Change in Mountain Regions




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.

An Interdisciplinary Graduate Program

Thank you very much for your attention

Cooperation Partners

Bhola R. Gurjar	*Indian Institute of Technology (IIT), Department of Civil Engineering, Roorkee , India*
Stefan Norra	*Institute of Mineralogy and Geochemistry (IMG), Karlsruhe Institute of Technology (KIT)*
Yuesi Wang, Guiqian Tang, Xin Jinyuan	*Chinese Academy of Sciences (CAS), Institute of Atmospheric Physics (IAP), Beijing*
Longyi Shao	*Chinese University of Mining and Technology (CUMTB), Beijing*
Kuang Cen	*Chinese University of Geosciences (CUG), Beijing*
Jose Agustín García, Gerardo Ruiz	*Universidad Nacional Autonoma de Mexico (UNAM), Mexico City*
Rainer Schmitz, Ricardo Muñoz	*Universidad de Chile (UdC), Santiago de Chile*
Barbara Lenz, Andreas Justen	*German Aerospace Center (DLR), Berlin, Germany*
Ulrich Franck	*Helmholtz Zentrum für Umweltforschung (UFZ), Leipzig, Germany*
Annette Peters, Alexandra Schneider	*Helmholtz Zentrum München (HMGU), Institute for Epidemiology, Munich, Germany*
Johannes Rehner, Ricardo Jordán	*Economic Commission for Latin America and the Caribbean (ECLAC/CEPAL) in the UN*