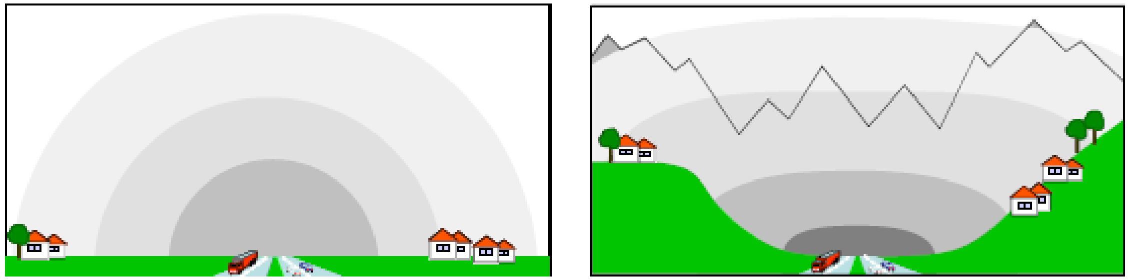
Assessment of air quality and mixing-layer height in an Alpine valley from measurements and numerical modelling

S. Emeis, K. Schäfer, R. Forkel, F. Obleitner[2], P. Suppan
Institute for Meteorology and Climate Research
Atmospheric Environmental Research Division (IMK-IFU)
Forschungszentrum Karlsruhe GmbH
Kreuzeckbahnstr. 19
82467 Garmisch-Partenkirchen, Germany
E-mail: stefan.emeis@kit.edu

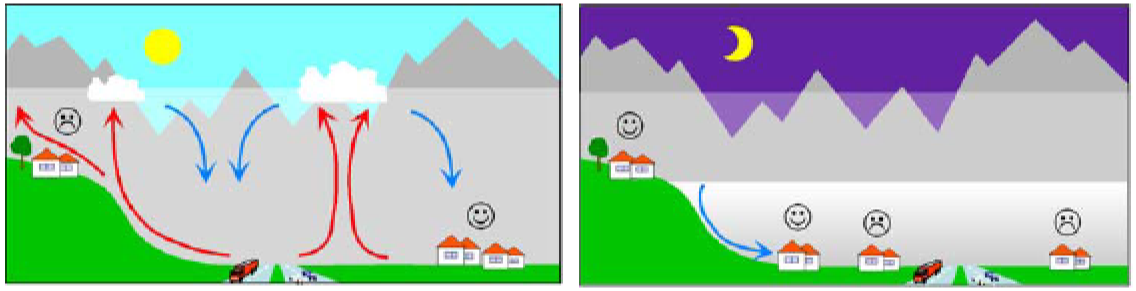
[2]Institute of Meteorology and Geophysics, University of Innsbruck, Innsbruck, Austria

Alpine valleys are strongly vulnerable

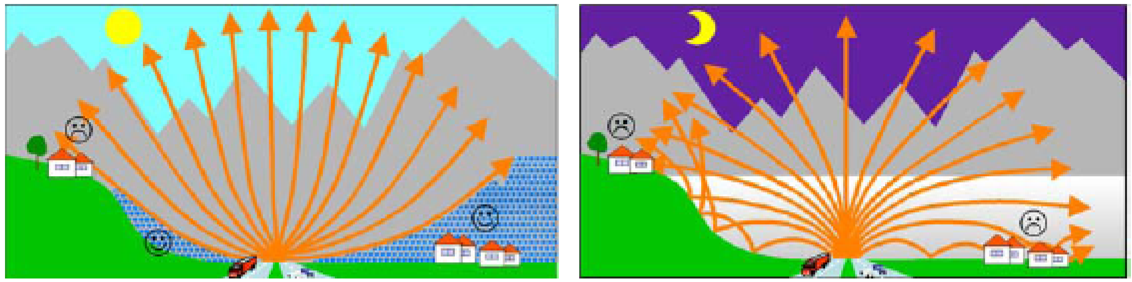
- due to their geometrical shape (limited space for dispersion)
- due to the meteorological conditions (frequent inversions)
- due to high anthropogenic pollutant emissions
- due to high anthropogenic noise emissions



higher air pollution



restricted vertical exchange



unfavourable noise propagation

Here, an assessment of air quality and meteorological conditions is done

- by measurements of pollutant emissions and concentrations in winter 2005/2006

- by measurements of the mixing-layer height in winter 2005/2006

- by numerical modelling with a online-coupled mesoscale meteorology-chemistry model (MCCM)

<u>for noise see:</u> Heimann et al. 2009: Combined evaluations of meteorological parameters, traffic, noise, and air pollution in an Alpine valley. Submitted to Meteorol.Z.

ALPNAP project (Monitoring and Minimisation of Traffic-Induced Noise and Air Pollution Along Major Alpine Transport Routes)

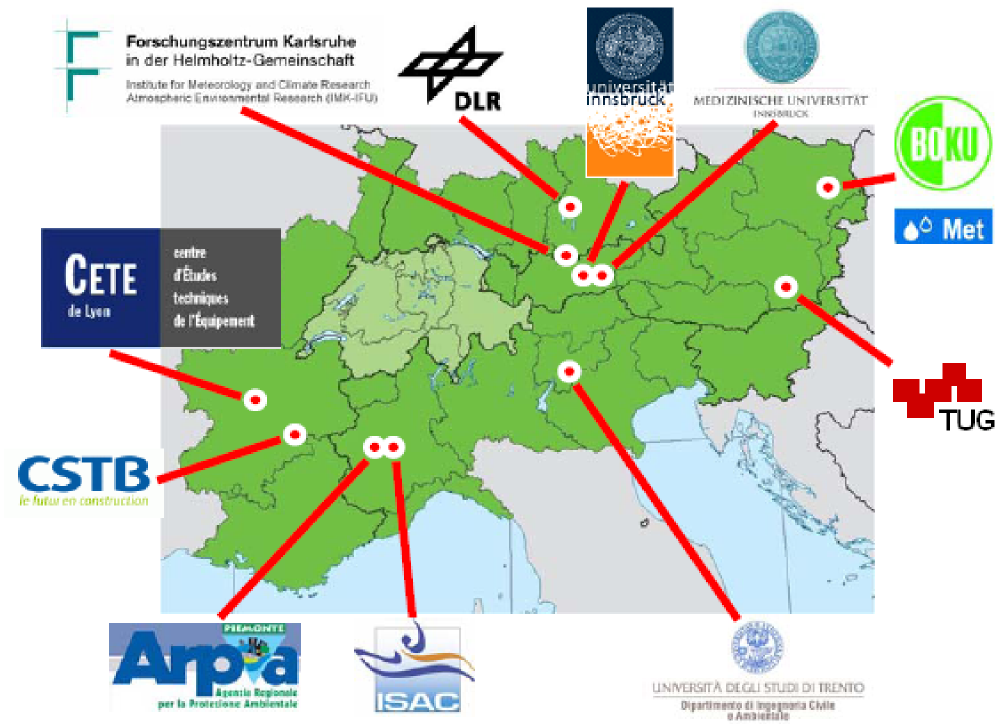
KIT
Karlsruhe Institute of Technology

ALPNAP

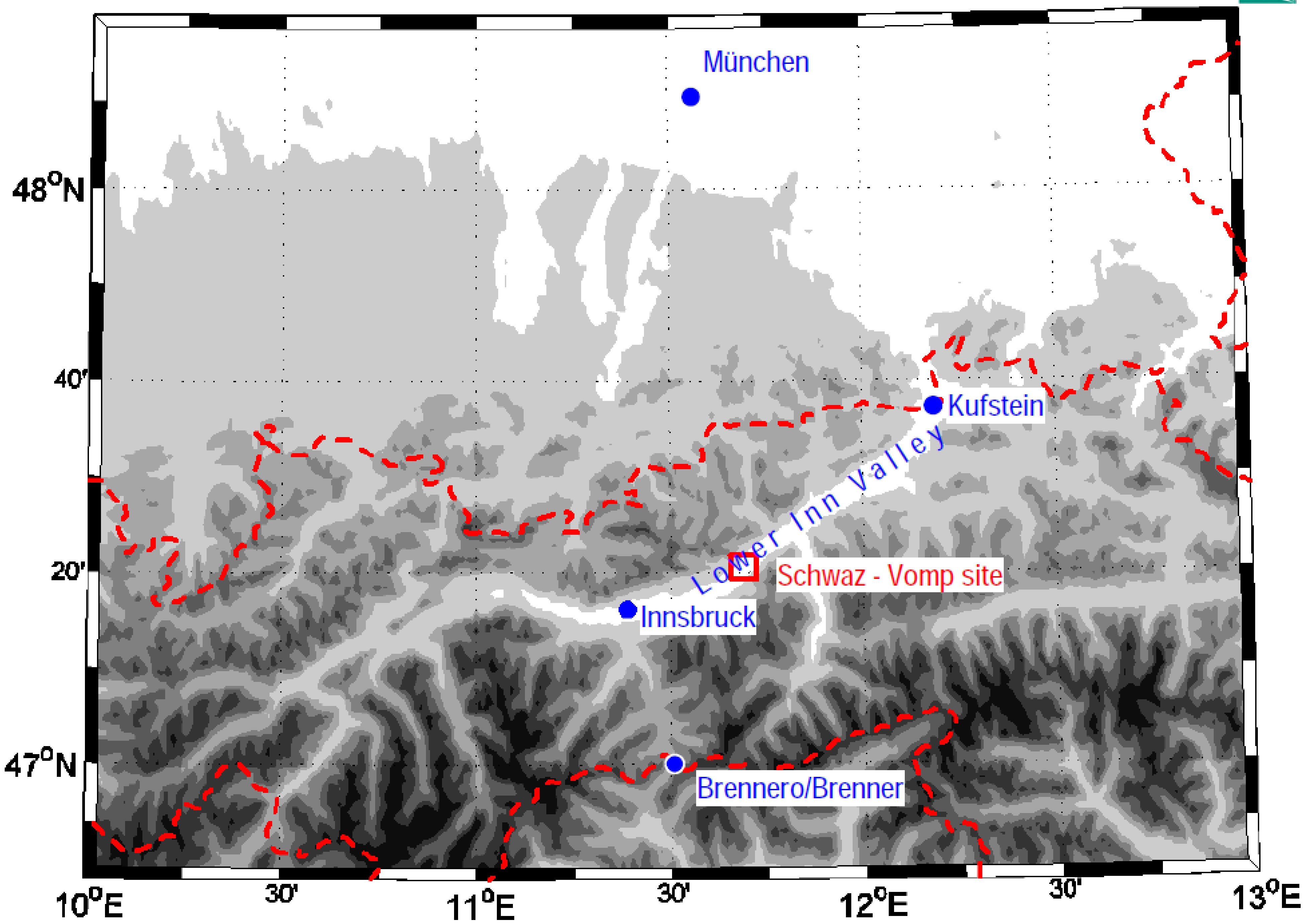
This project has received European Regional Development Funding through the INTERREG IIIB Community Initiative

Alpine Space

Interreg III B



The project has received European Regional Development Funding through the INTEREG IIIB Community Initiative.


München
48°N
40'
Kufstein
Lower Inn Valley
20'
Schwaz - Vomp site
Innsbruck
47°N
Brennero/Brenner
10°E
30'
11°E
30'
12°E
30'
13°E

(a)

(b)

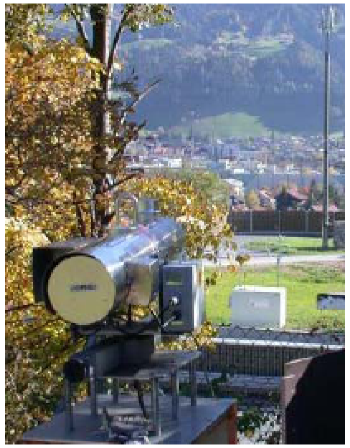
(c)

(d)

(e)

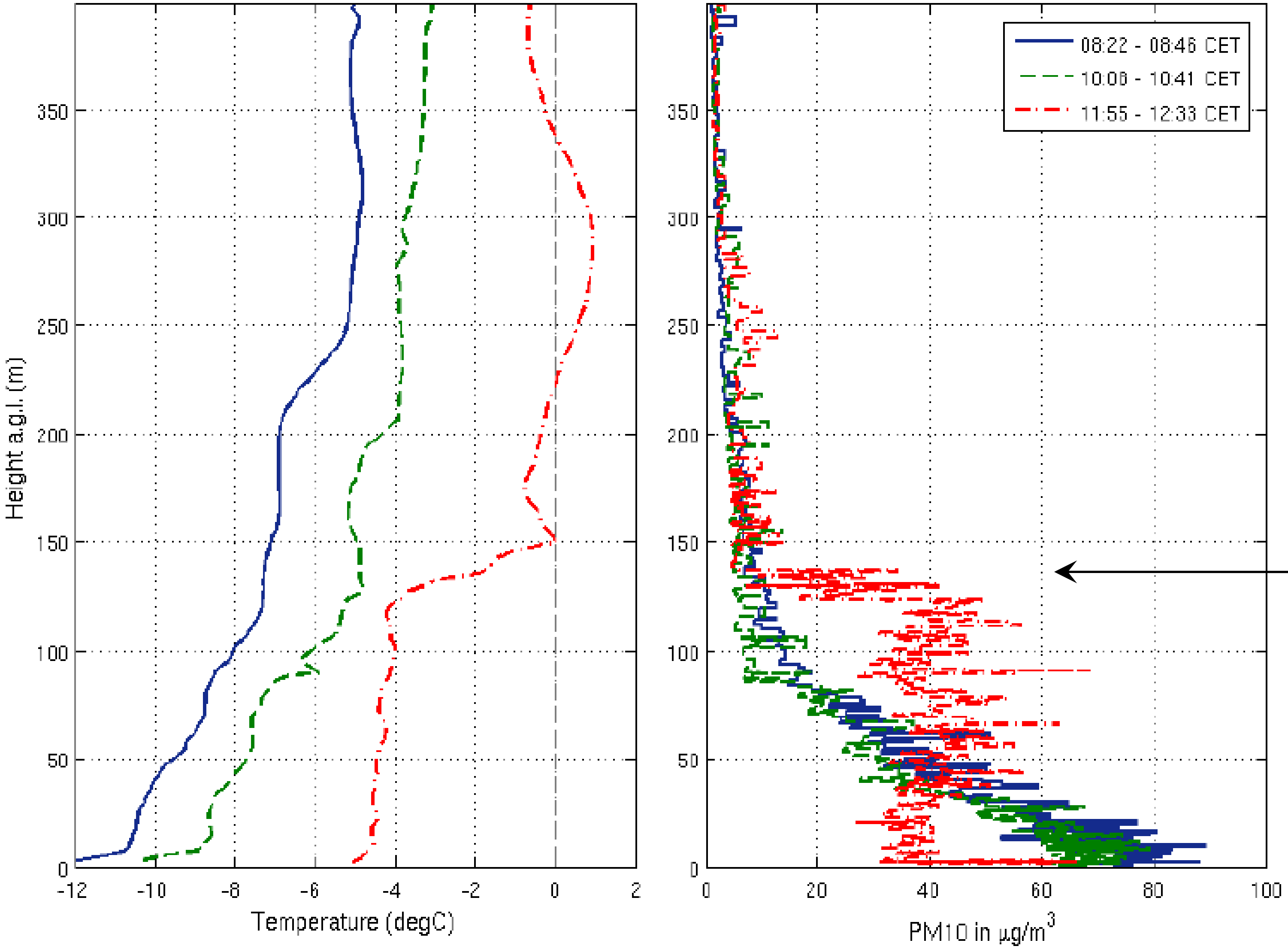
(f)

(g)



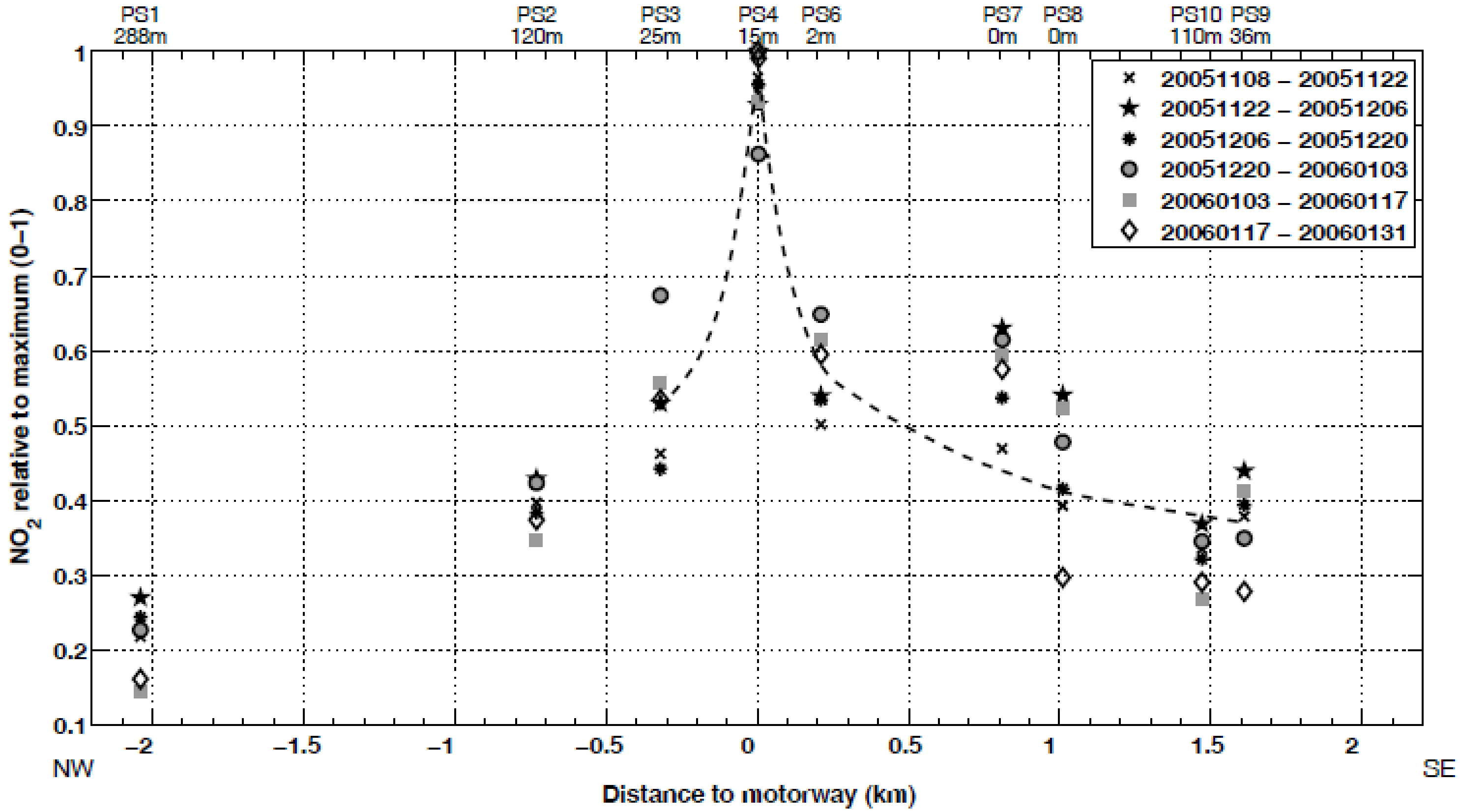
(h)

Results from tethered balloon measurements (Jan 13, 2006)

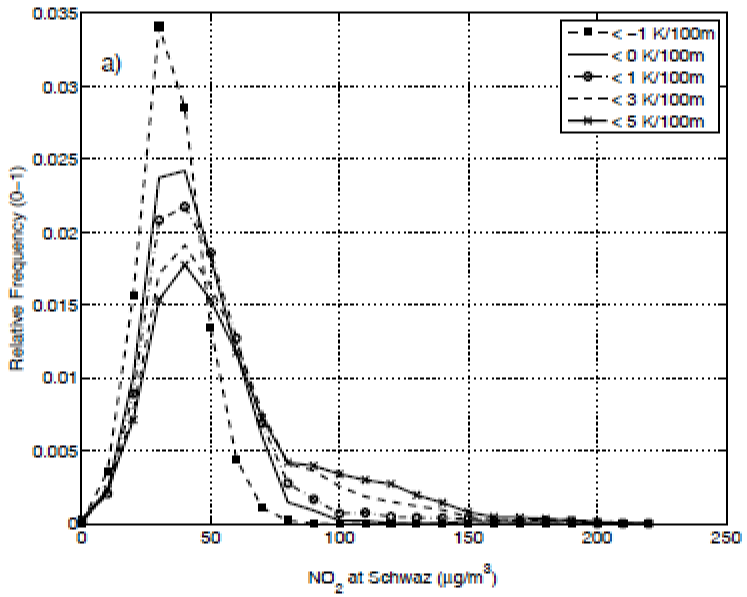


mixing underneath a persisting inversion

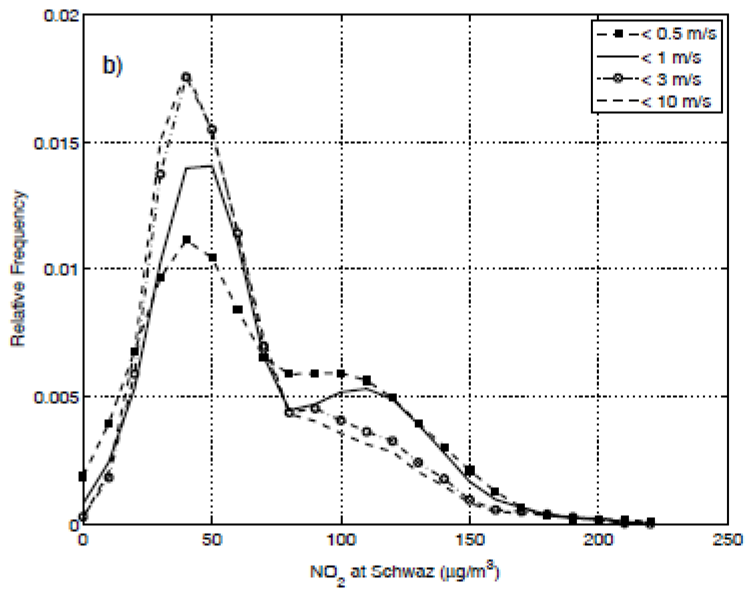
two week averages of NO_2 concentration from passive samplers on both sides of a motorway



Relative frequencies of NO_2 concentrations for the whole period (Nov 8, 2005 to Feb 4, 2006)



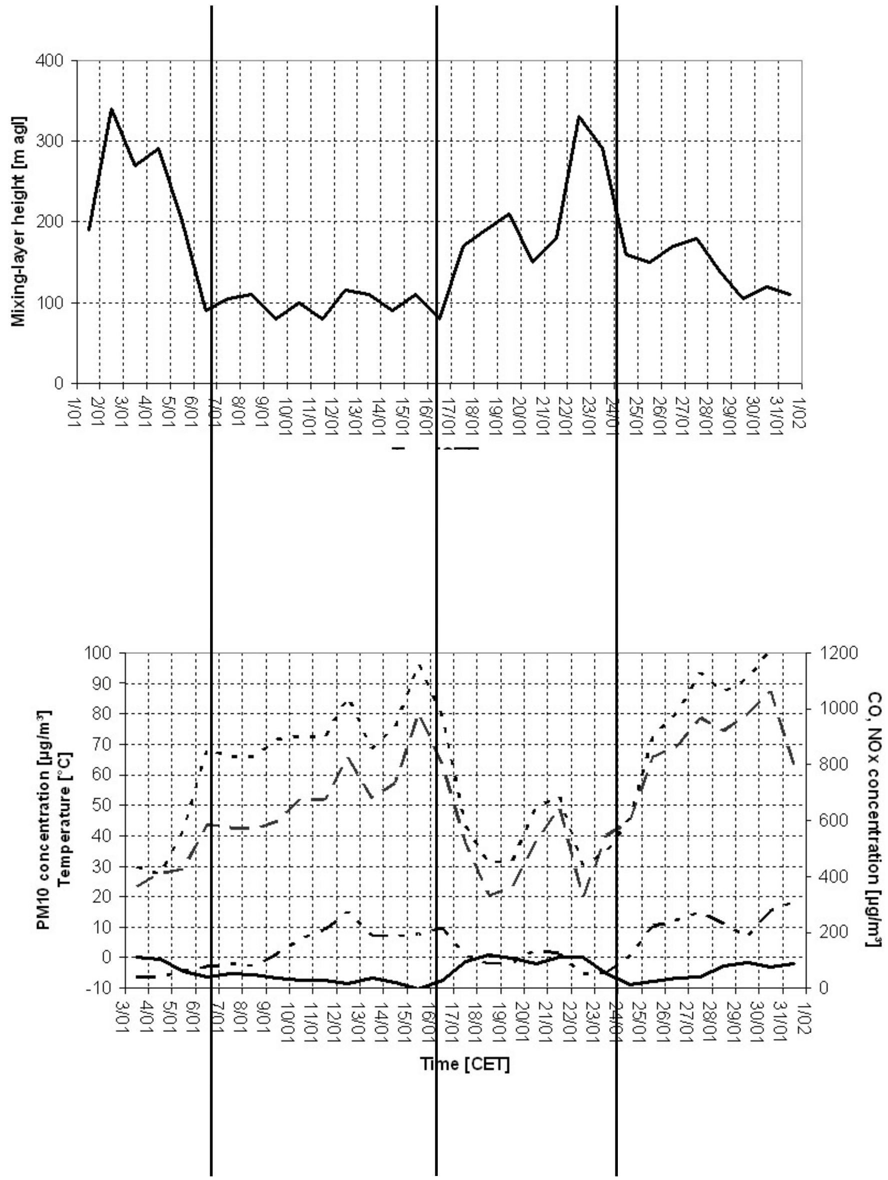
as function of thermal stability



as function of wind speed

Karlsruhe Institute of Technology

MLH and air pollution, daily data



MLH from SODAR data

CO and PM_{10} (two upper curves)

Multiple inversions from SODAR data

acoustic backscatter intensity wind direction

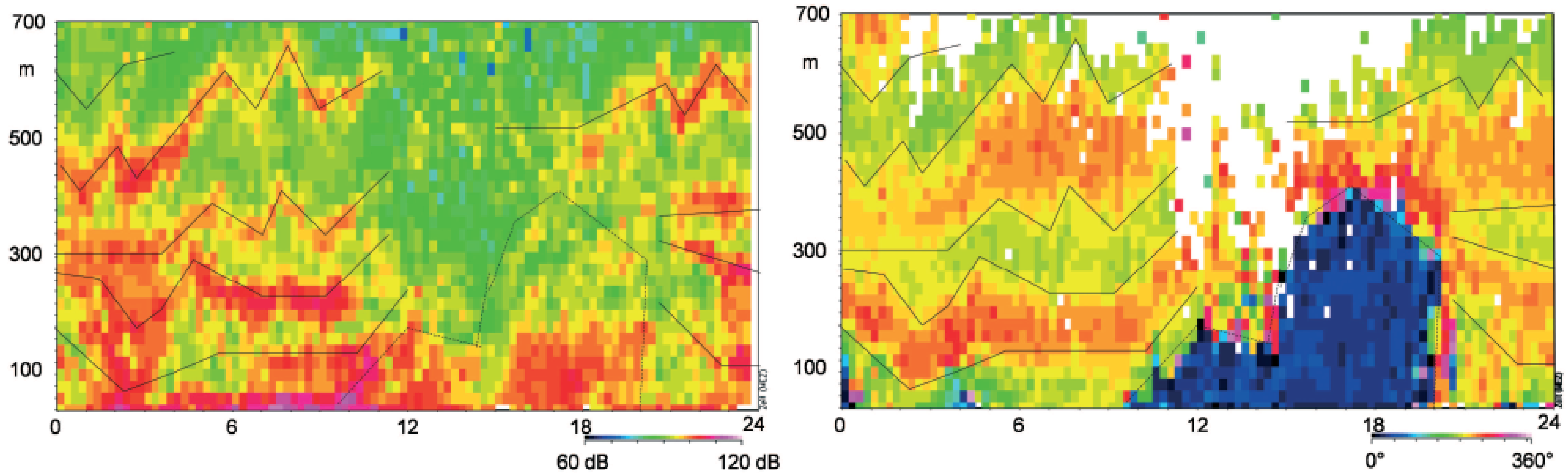


Figure 5: Acoustic backscatter intensity (left; purple and red: high, green: low) and wind direction (right; green: down-slope winds, red: down-valley winds, and blue: up-valley winds) from the sodar measurements on January 29, 2006. The lines in the two Figures have been analysed from the wind direction changes in the right-hand frame.

January 29, 2006

Inversion statistics from SODAR data for Jan 1-18, 2006

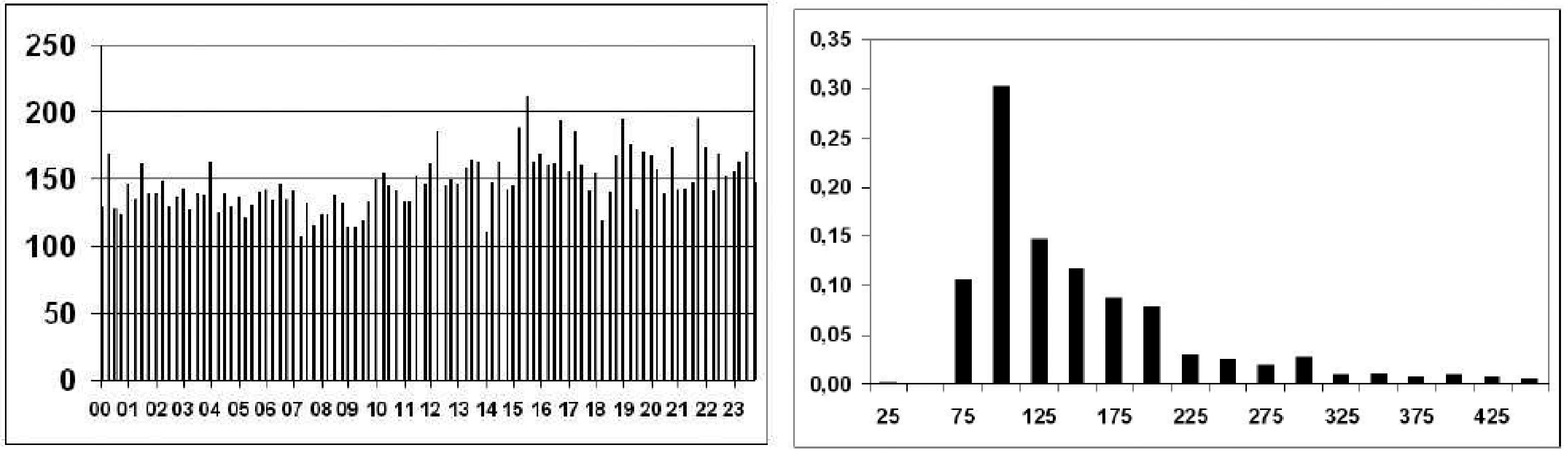


Figure 6: Mean diurnal variation of mixing layer height in m plotted against the hours of the day (left) and frequency distribution of the mean daily-averaged mixing layer height in % plotted against the height in m (right) in the Inn valley for January 1–18, 2006.

mean diurnal variation (left)

frequency distribution (right)

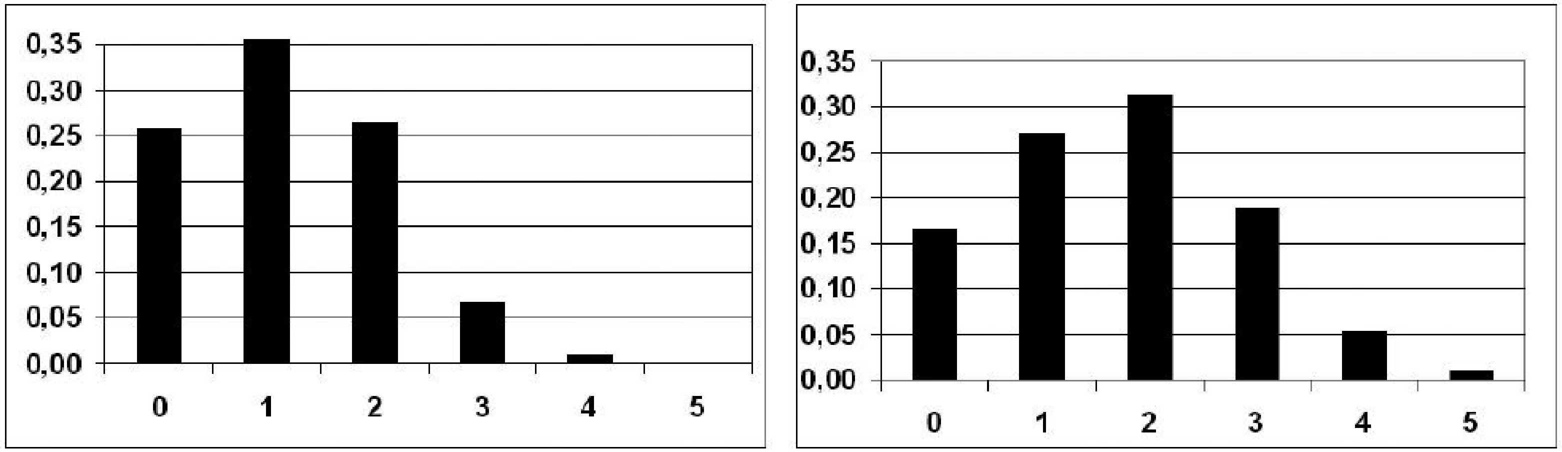


Figure 7: Frequency of the occurrence of multiple lifted inversions in % in the height interval between 140 and 1000 m from ceilometer data (left) and in the height interval between 60 and 1000 m for the sodar data (right). "0" means that no lifted inversion was detected.

number of simultaneously existing inversions

ceilometer (left)
SODAR (right)

Regional modelling

MCCM (Mesoscale climate chemistry model)

Meteorological part

- *Based on MM5*
- *Non-hydrostatic*
- *Nesting capability*
- *Soil and snow model*

Online chemistry part

- *RADM2, RACM, RACM-MIM*
- *Photolysis model*
- *Aerosol module MADE/SORGAM*
- *Biogenic emission module*

Input *Any met. input suitable for MM5, initial concentrations of chemical compounds and hourly anthropogenic emissions in MM5-format*

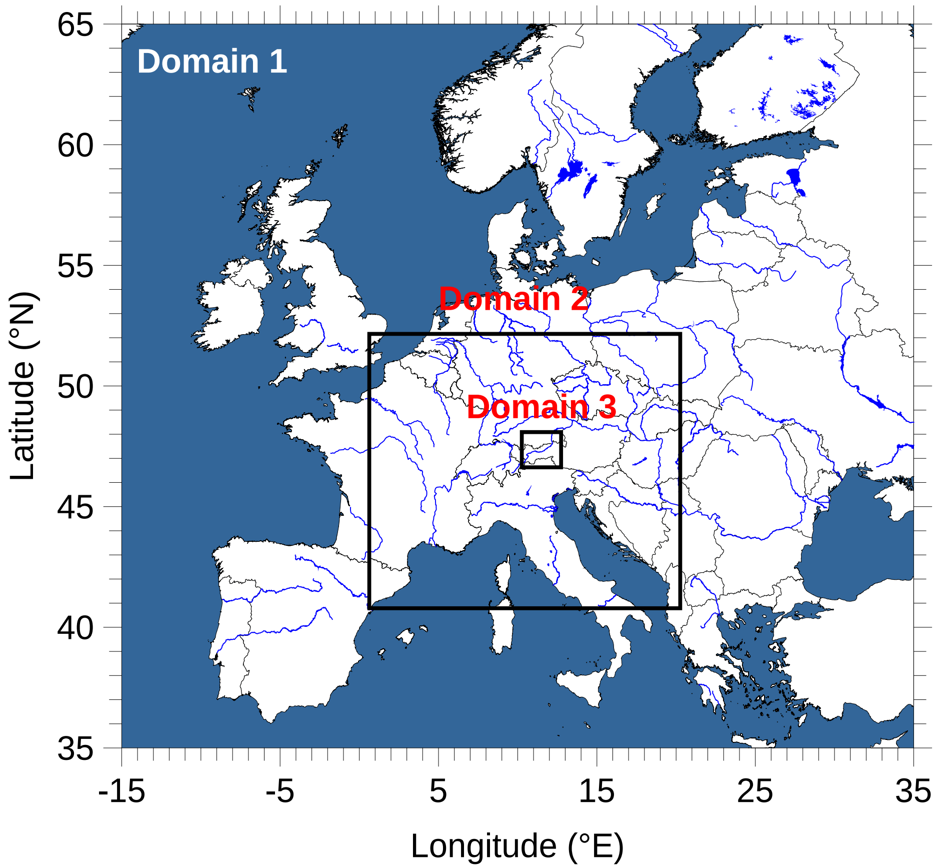
Output *3-d meteorological fields, snow height, photolysis frequencies, concentrations of chemical compounds in the gas and particle phase, …*

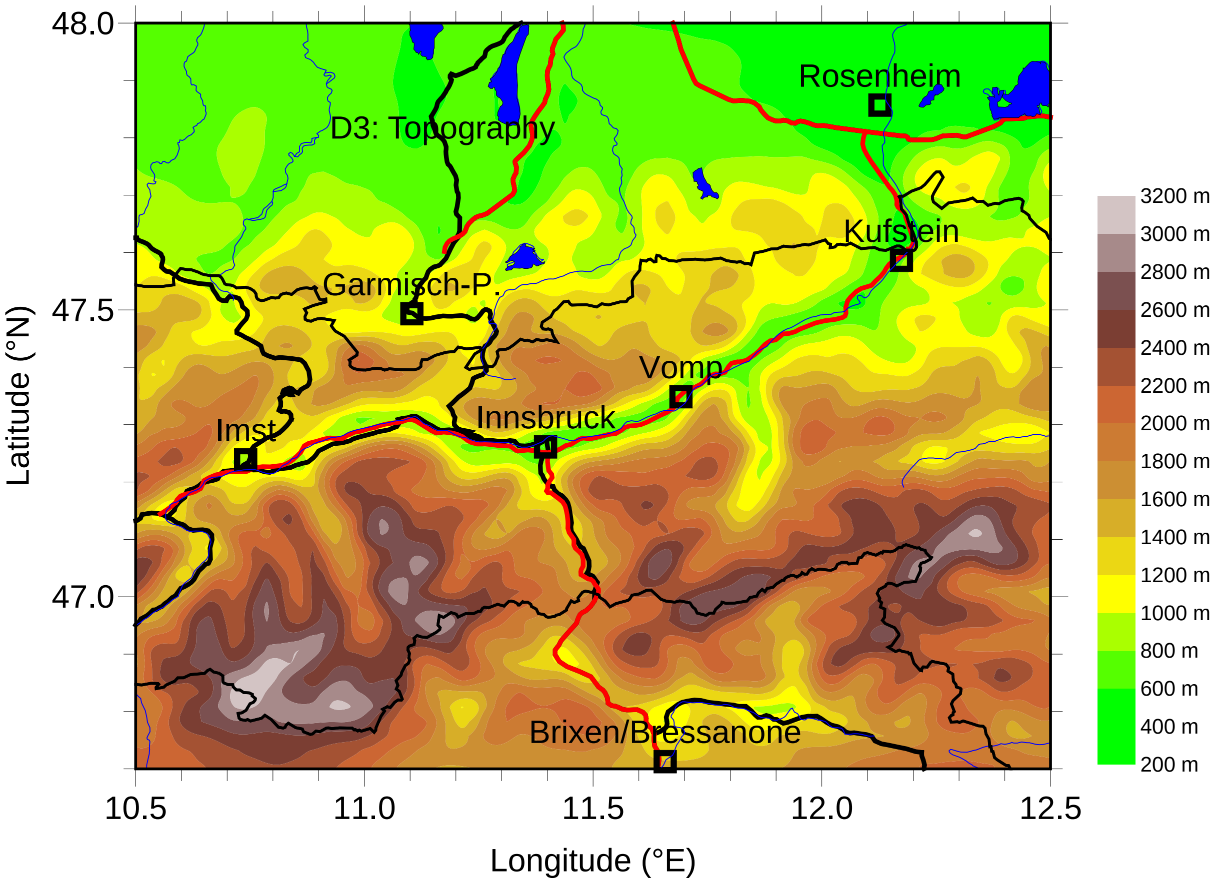
Applications *Episodes and sensitivity studies*
Real time air quality simulations
Regional climate chemistry simulations

Grell et al. 2000, Atmospheric Environment

Setup of regional modelling

- **Continuous simulation**
- **Three nested domains with horizontal resolution 60 km, 12 km, and 2.4 km**
- **Meteorological boundary conditions for Domain1 from NCEP reanalysis**



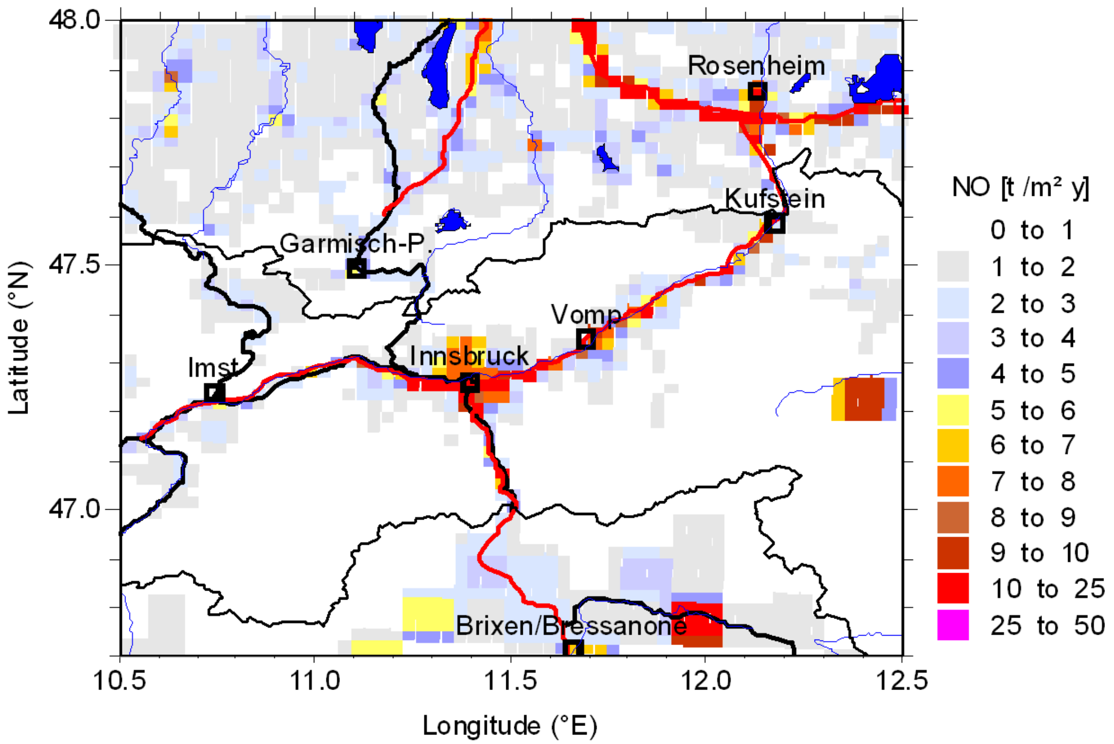


Emissions for regional modelling

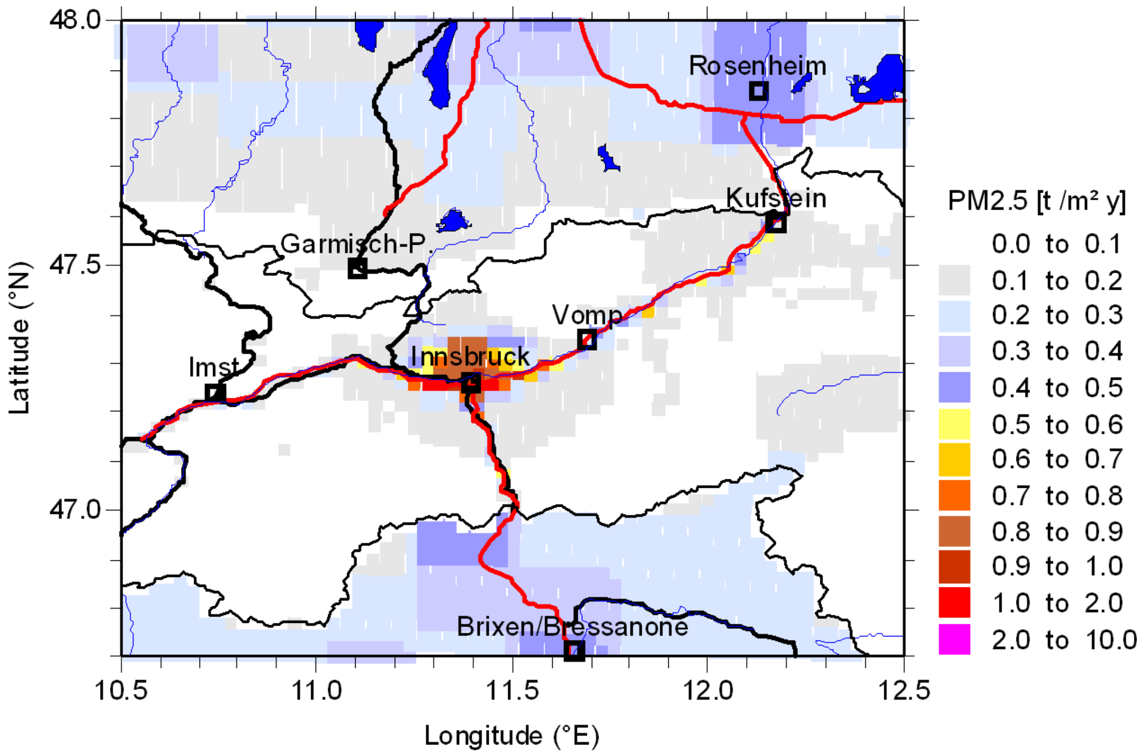
Emissions for all model domains needed

- **Five different data sets (not consistent)**
- **PM emissions are probably underestimated**

D3: NO emissions for all sectors

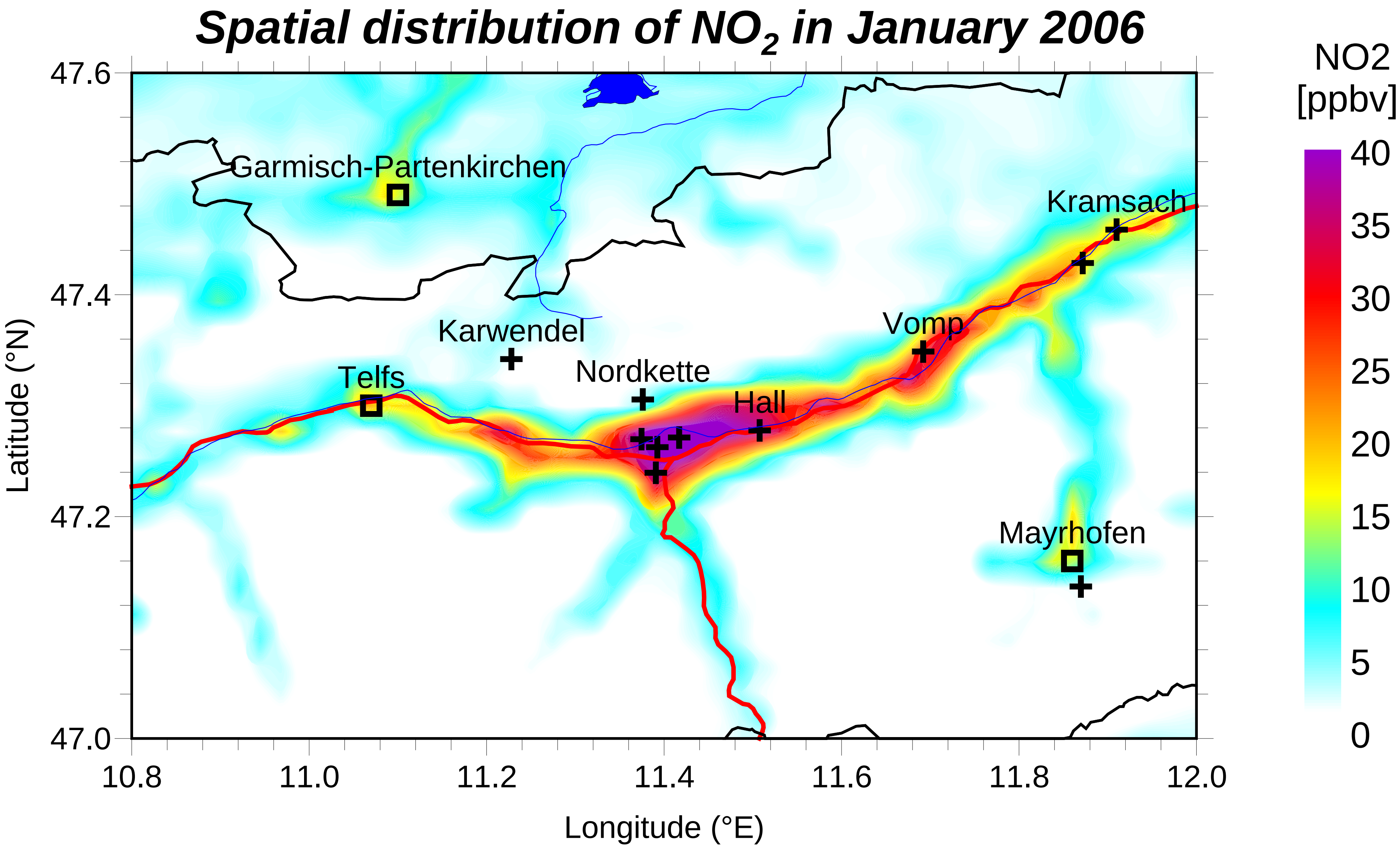


D3: PM2.5 emissions for all sectors



Road traffic emissions for Tyrol: U. Uhrner, Univ. Graz; Amt der Tiroler Landesregierung
Domestic heating emissions for Tyrol: Amt der Tiroler Landesregierung

Regional modelling results

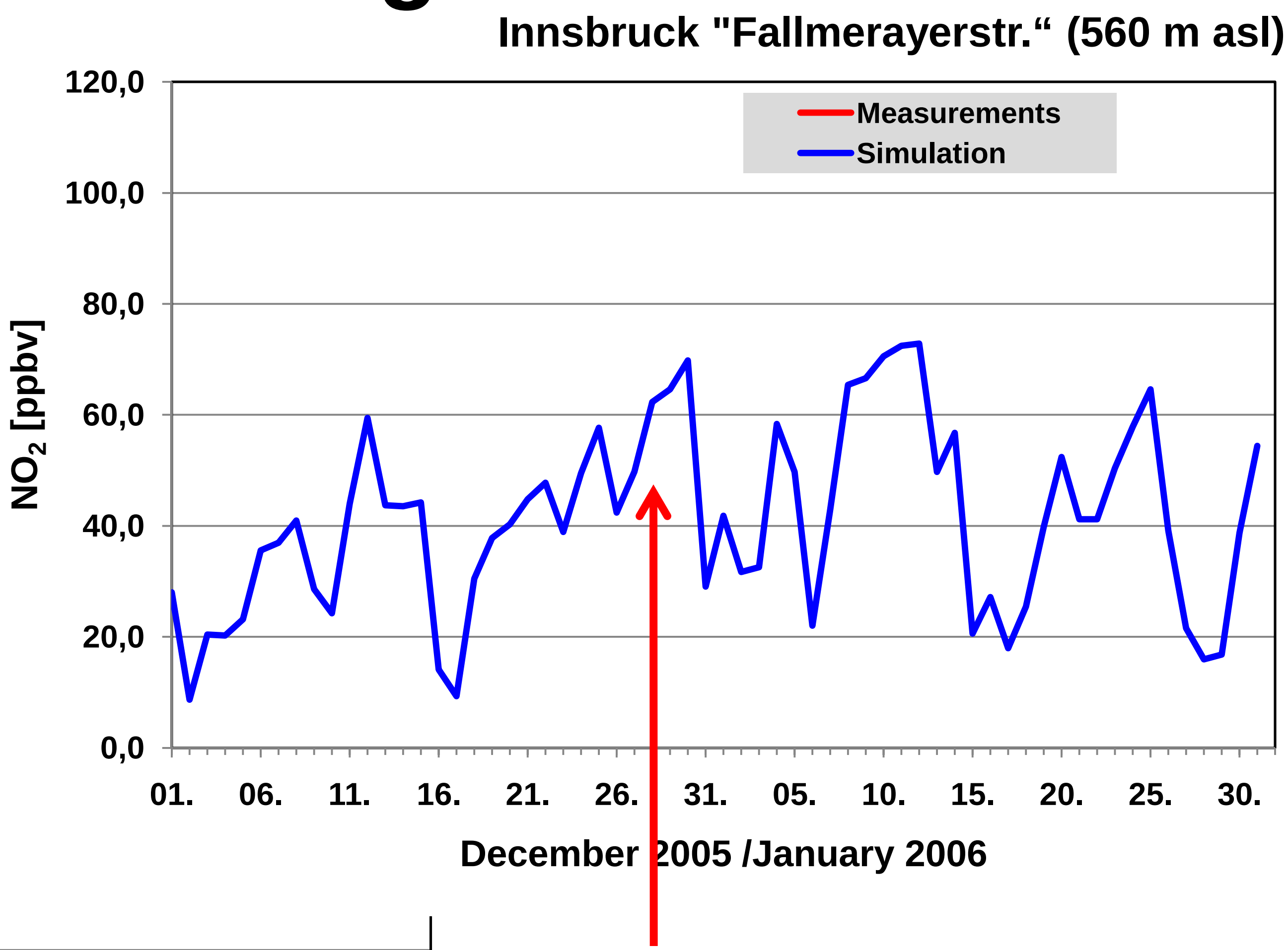


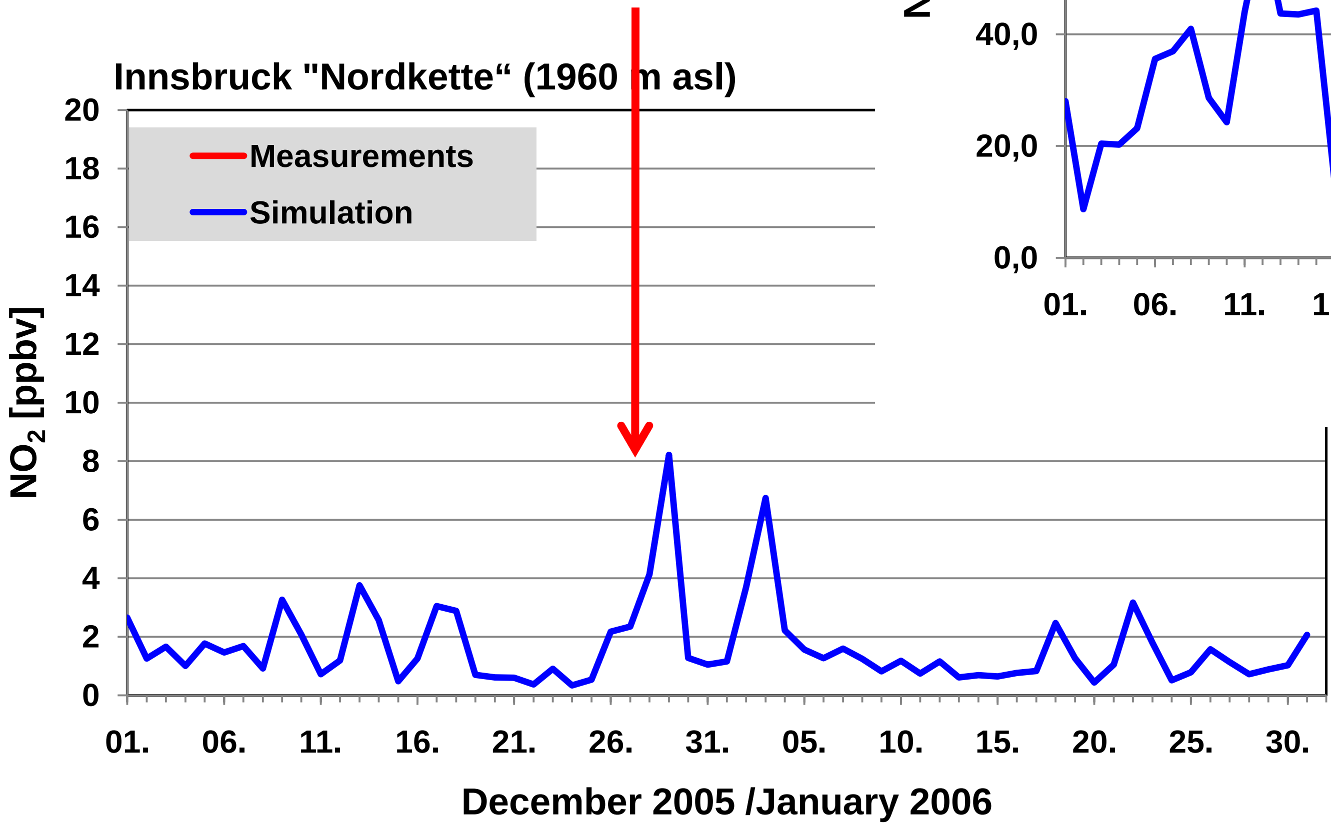
Crosses mark measuring stations

Regional modelling results

Daily averaged NO_2 concentrations at the Northern side of the Inn valley („Nordkette“) and in the city of Innsbruck („Fallmerayerstr.“).

Shortly before end of December the model simulates higher concentrations in the city and lower concentrations at the mountain site due to a too cold boundary layer in the simulation (arrows).





Observations: Amt der Tiroler Landesregierung Abt. Waldschutz / Luftgüte

Conclusions

data from an extreme period with long-lasting snow cover were presented

spatial distribution of near-surface pollution was assessed

vertical profile information was available from tethered balloon ascents
and surface-based remote sensing (SODAR, ceilometer)

correlation between mixing-layer height and pollutant concentrations was found

model simulations supported measurement results

model simulations allow for an assessment of the spatial distribution of air pollutants

Thank you very much for your attention

KIT – die Kooperation von
Forschungszentrum Karlsruhe GmbH
und Universität Karlsruhe (TH)

Forschungszentrum Karlsruhe
in der Helmholtz-Gemeinschaft