Two years air quality study by DOAS within Beijing

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INSTITUTE FOR METEOROLOGY AND CLIMATE RESEARCH, ATMOSPHERIC ENVIRONMENTAL RESEARCH (IMK-IFU)

- Scientific questions
- Process studies
  - Methodology
  - Influences upon air pollution
- Future tasks

Scientific questions for air quality in Beijing

Origin of frequently occurring air pollution events

Origin of pollutants - urban agglomerations one of the most important sources for pollutants

Local and regional wind systems - bring fresh air masses and limit air pollution

Role of mixing layer height (MLH) – mountains West to North

Process studies

Influences upon air pollution

Air quality studies

Continuous determination of mixing layer height (MLH) by ceilometer

Limits the vertical distribution of emitted air pollutants with consequences for dilution and transport

Essential for the determination of speed and range of vertical dispersion

Influenced by future climate change and thus important for quality of living in large cities

MLH influence upon air pollution in urban and sub-urban area

Hannover, Munich, Augsburg, Budapest, Zurich Airport, Mexico City International Airport, Athens International Airport, Paris CDG

- Correlation with MLH smallest inside street canyons
- Correlation with MLH larger in winter than in summer
- Influences of MLH upon CO, NO_2 and PM_{10} concentrations in the order of 20 %, up to 50 %

➔ therefore better MLH determination necessary

➔ deployment of ceilometers for continuous operation

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

Wind influences upon air pollution

- Under strong background flows:
  reduced concentrations for all pollutants without distinct maxima and minima of diurnal cycle

- Under the development of local flows:
  high concentrations of air pollutants

- Influences of wind speed upon CO, NO_2 and PM_{10}:
  in the order of 20 %

Schäfer, K., Emeis, S., Hoffmann, H., Jahn, C., Müller, W., Heits, B., Haase, D., Drunkenmölle, W.-D., Bächlin, W., Schlünzen, H., Leitl, B., Pascheke, F., Schatzmann, M.: Field measurements within a quarter of a city including a street canyon to produce a validation data set. International Journal of Environment and Pollution, 25, 1/2/3/4, 201-216, (2005).

Dandou, A., Tombrou, M., Schäfer, K., Emeis, S., Protonotariou, A.P., Bossioli, E., Soulakellis, N. Suppan, P.: A comparison between modelled and measured mixing layer height over Munich. Boundary-Layer Meteorology 131, 425–440 (2009).

Air quality studies in Beijing

Comparison motorway with background concentrations

- diurnal variations
- influences upon gaseous concentrations:
  emissions, meteorology
- gases of interest for secondary aerosol formation

Path-averaged concentrations of air pollutants NO_2, SO_2, O_3, (benzene, toluene, xylene, NO, NH_3, HCHO)

- near / across a motorway April 2009 – March 2011
- commercial DOAS
- three retro-reflectors
- automatic operation

Instrument


Analysator
AR 502Z
Emitter/Receiver
Retro-reflector
OPSIS
12 prisms

Measurement sites

LAPC tower, ceilometer, DOAS from 13 July 2009 on

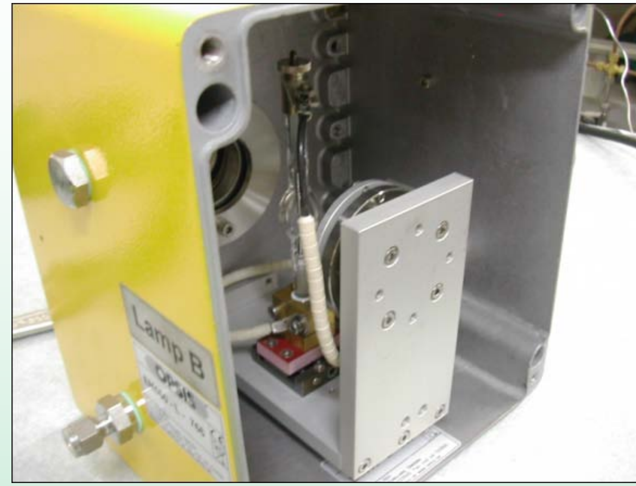
Path1- the first floor of the tower 126m(double)

Path2- on the roof in our courtyard 266m(double)

Path3- in the middle of the lampstandard 568m(double)

Calibration

Calibration system



Light source

Calibration cells

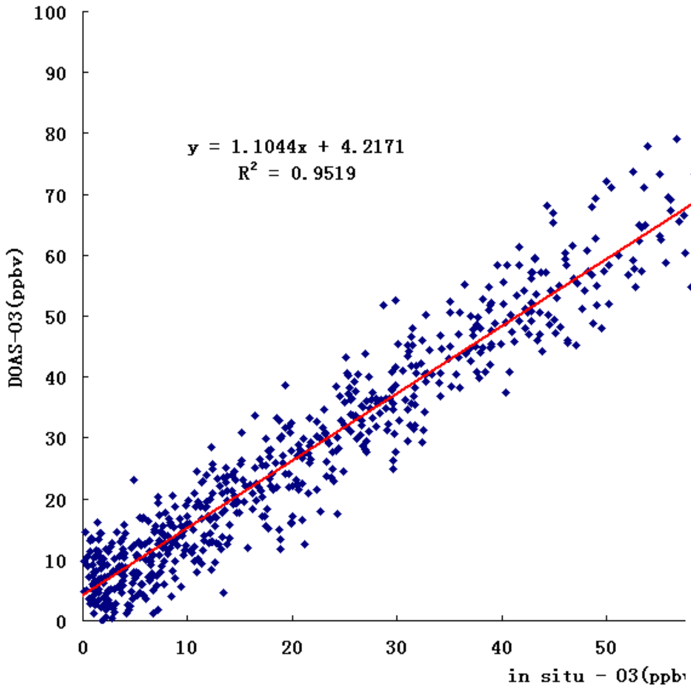
Ozone generator

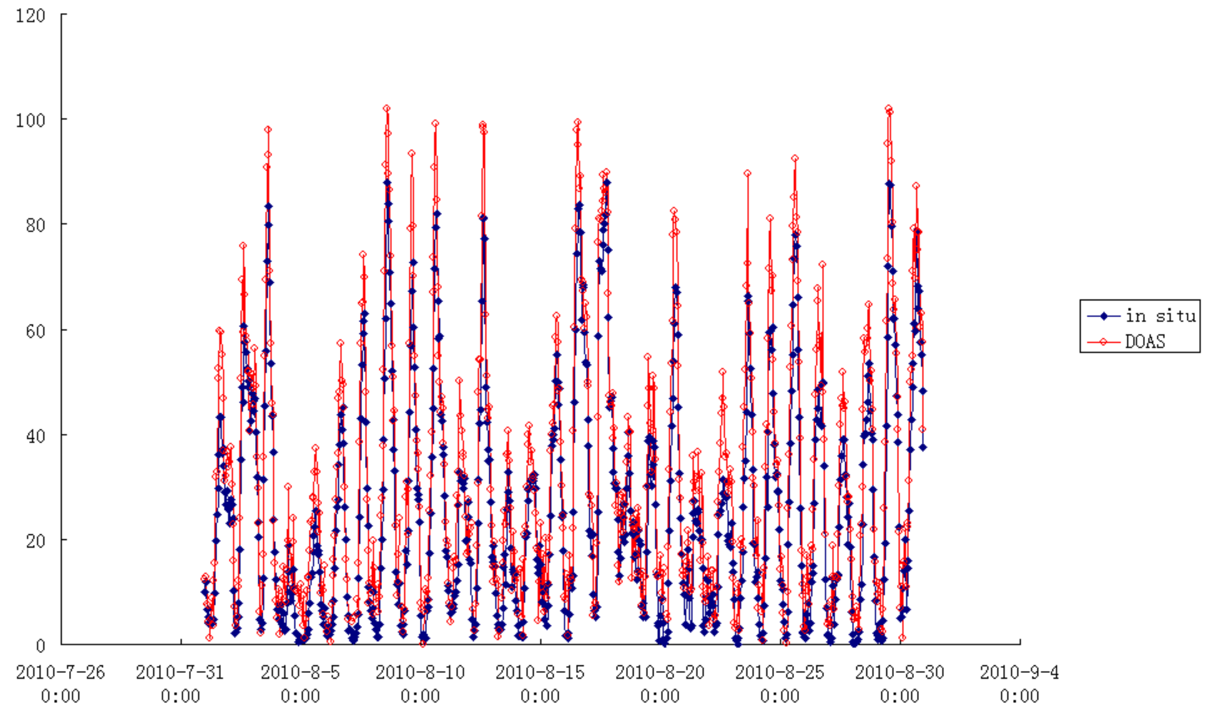
Comparison - instruments

- chemiluminescence NO-NO_2-NO_x analyzer
- UV photometric O_3 analyzer
- pulsed fluorescence SO_2 analyzer

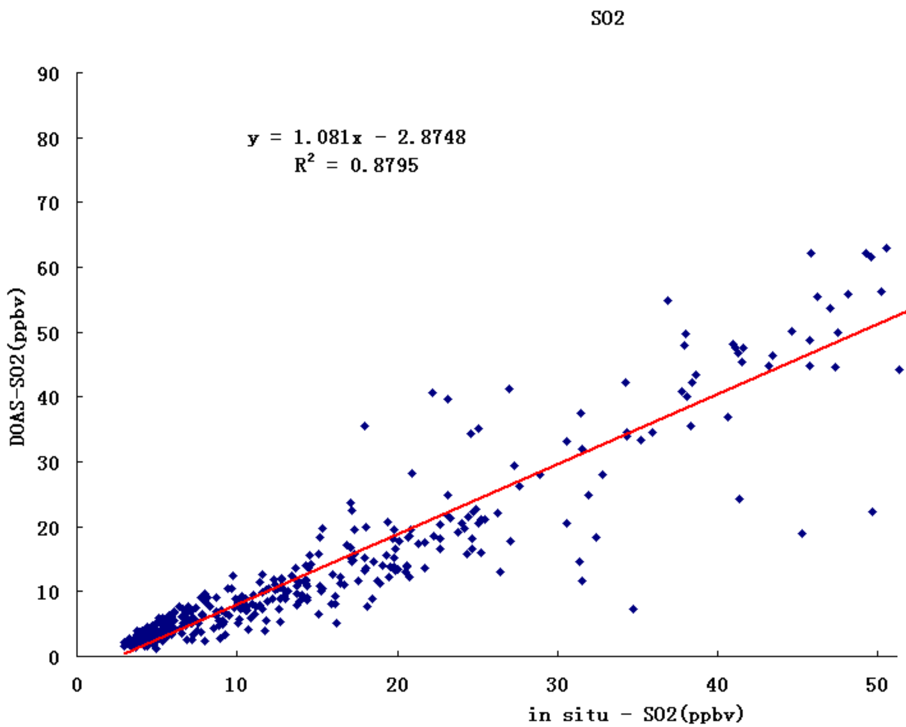
- GC/MS system (Finnigan Trace 2000/DSQ, ThermoFisher, USA) with fuse-silica capillary column for aromatic hydrocarbons

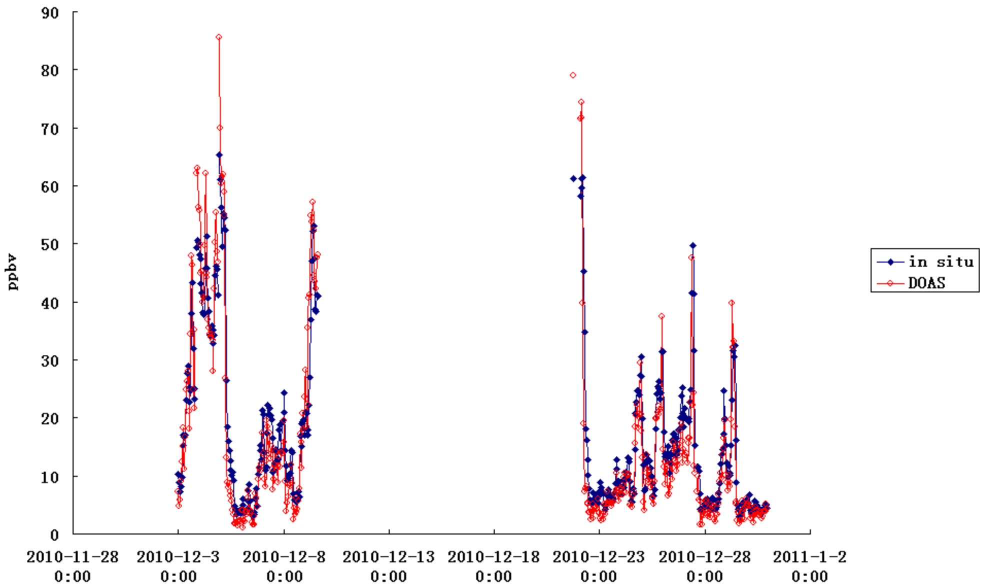
Comparison O_3 (path 2)



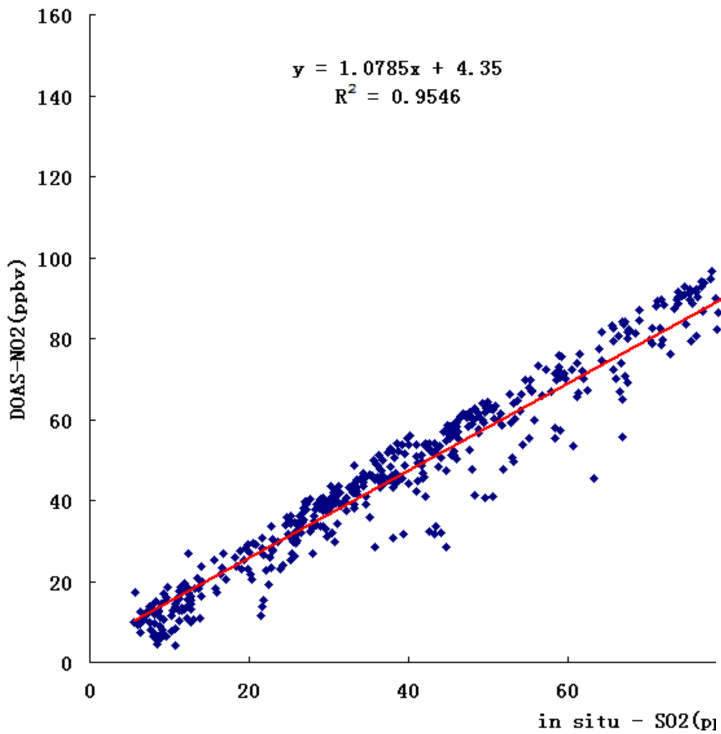


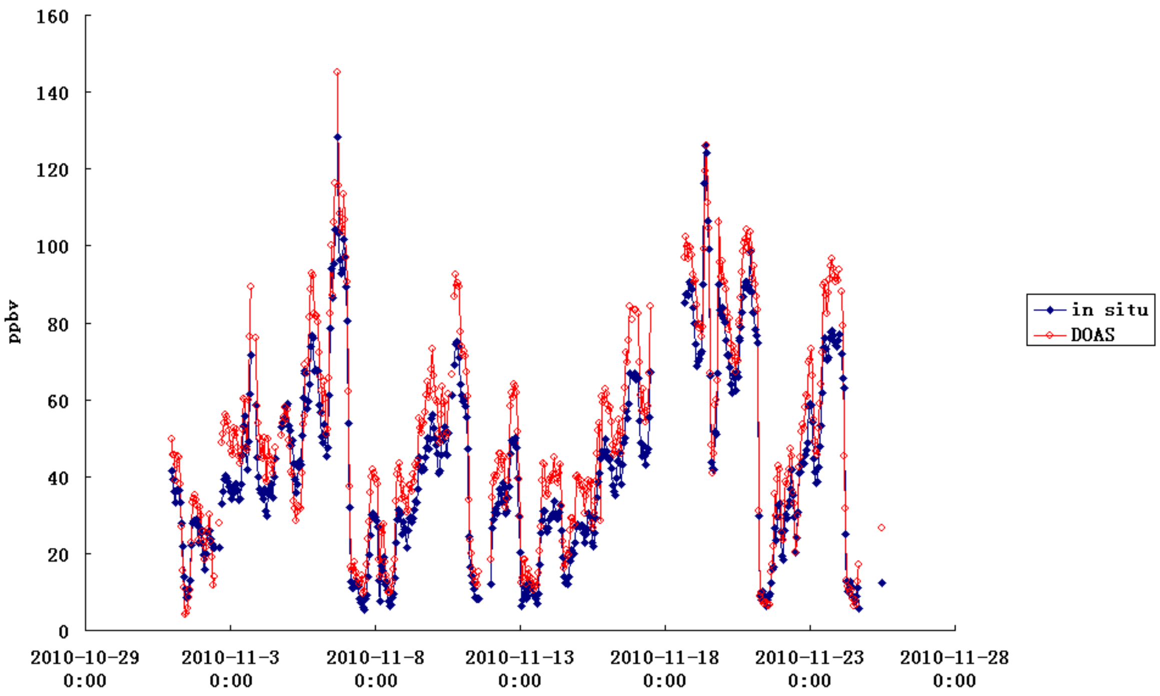
Comparison SO_2 (path 2)



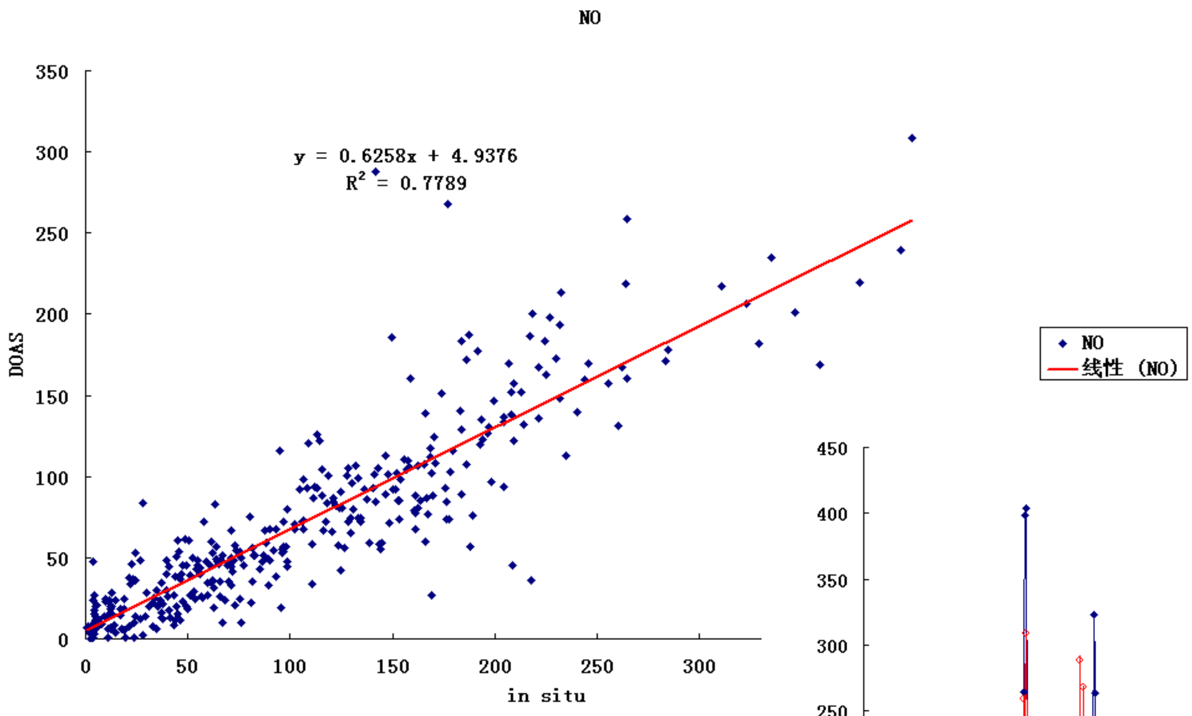


Comparison NO_2 (path 2)

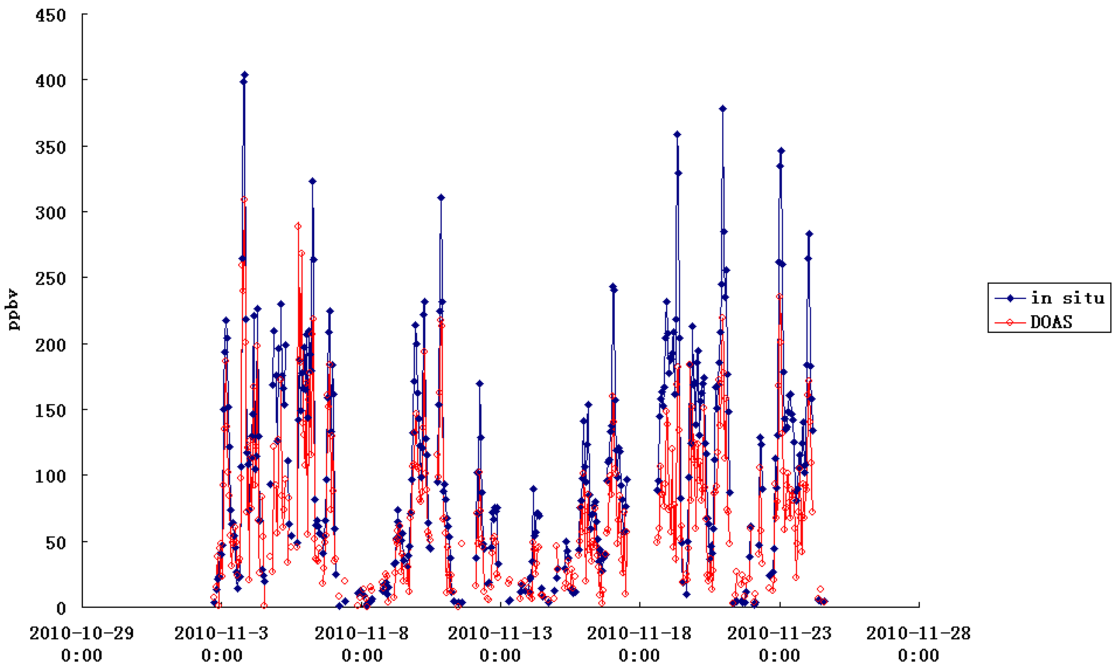




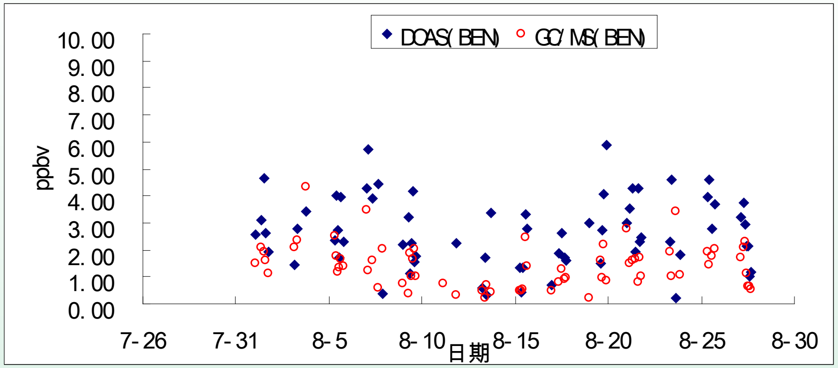
Comparison NO (path 1)

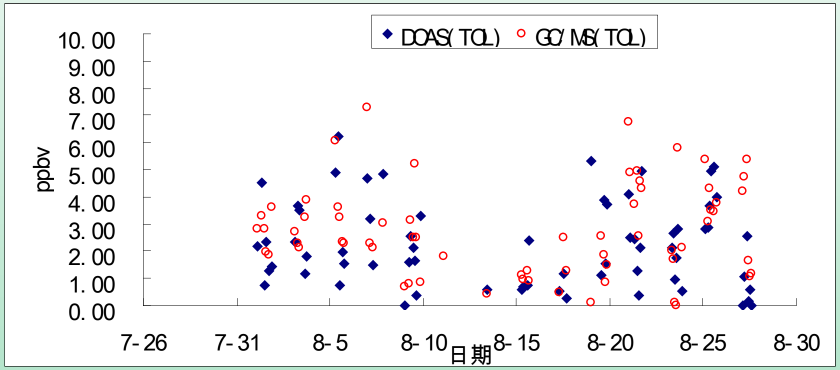


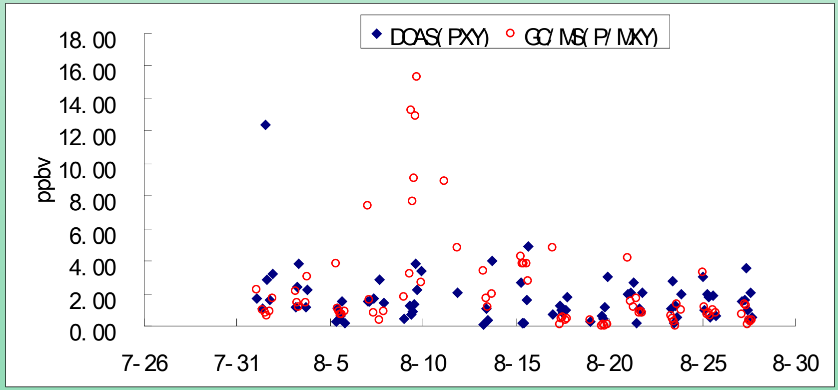
a good trend
but many negative data



Comparison Aromatic Hydrocarbons (path 2)







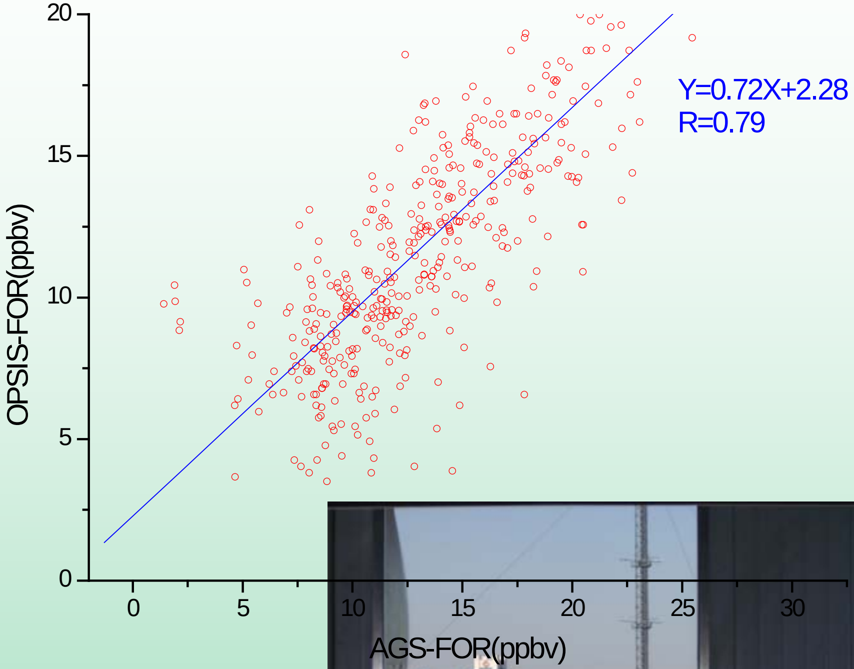
Average difference between DOAS and GC/MS:

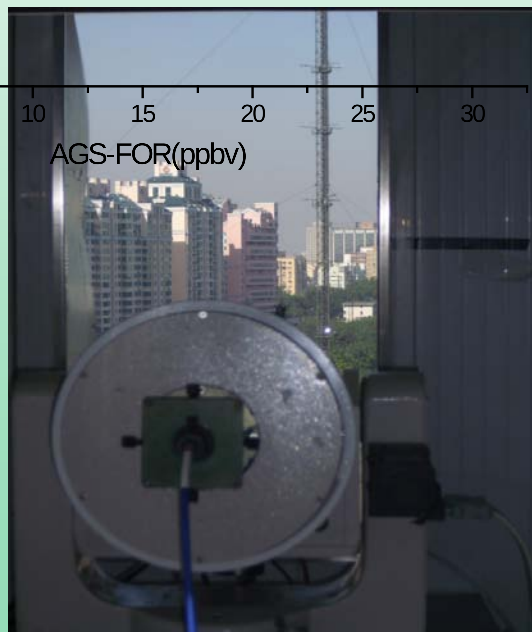
BEN: 0.94 ppbv (64% higher)

TOL: -0.56 ppbv (20% lower)

PXY: -0.49 ppbv

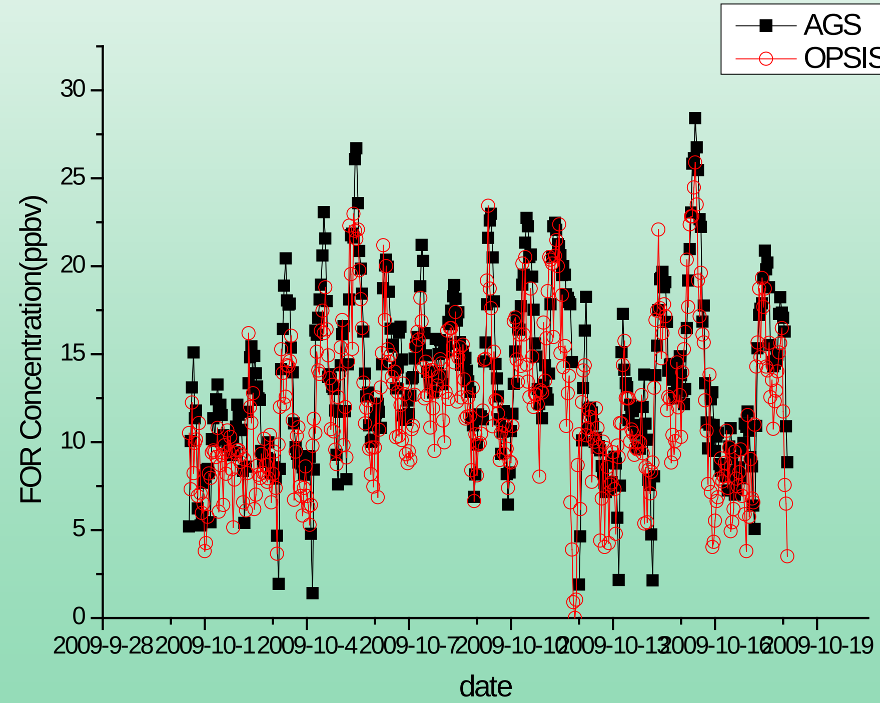
Comparison HCHO (path 3)





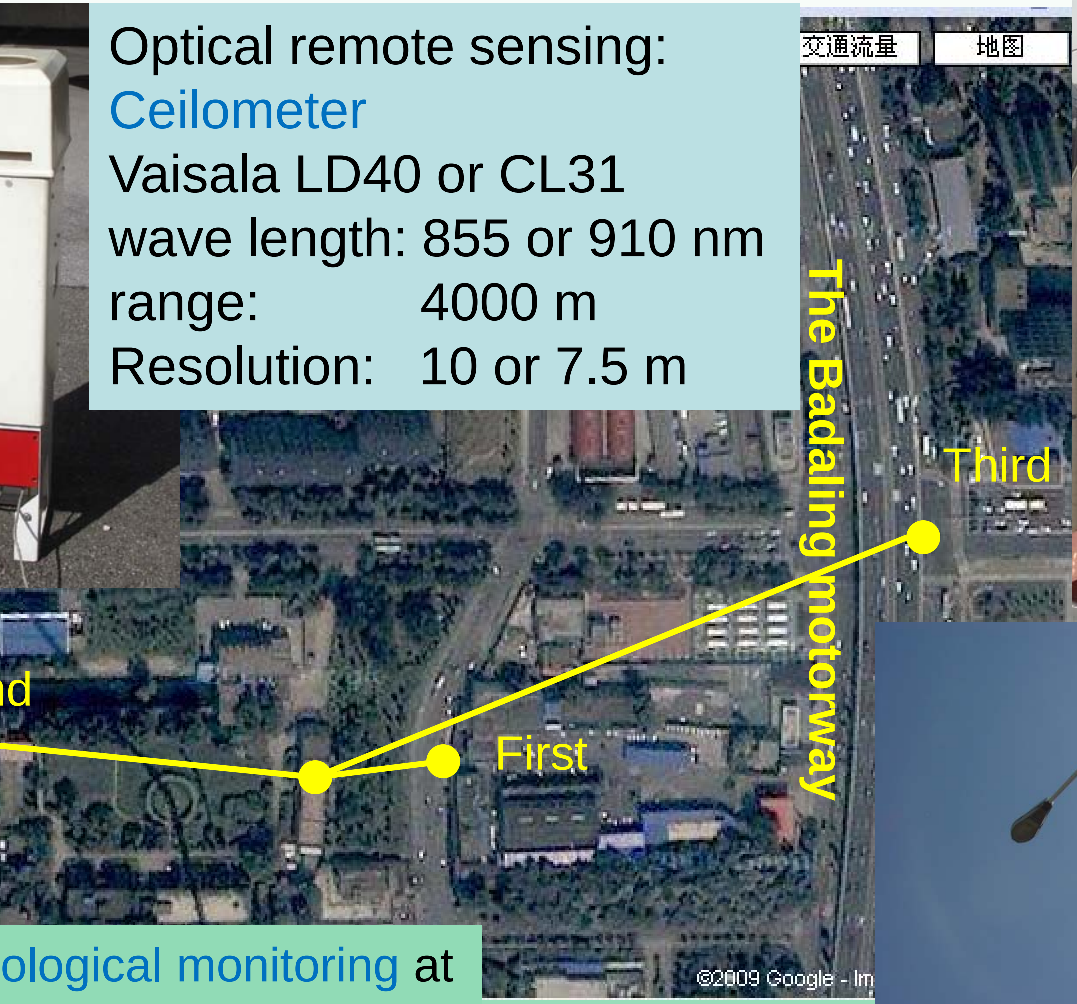
Two different DOAS systems:

- Mono-static with retro-reflectors
- Bi-static from Anhui Inst. Optics and Fine Mechanics, CAS



Continuous determination of mixing layer height by ceilometer since February 2009
DOAS installation April 2009 until July 2009

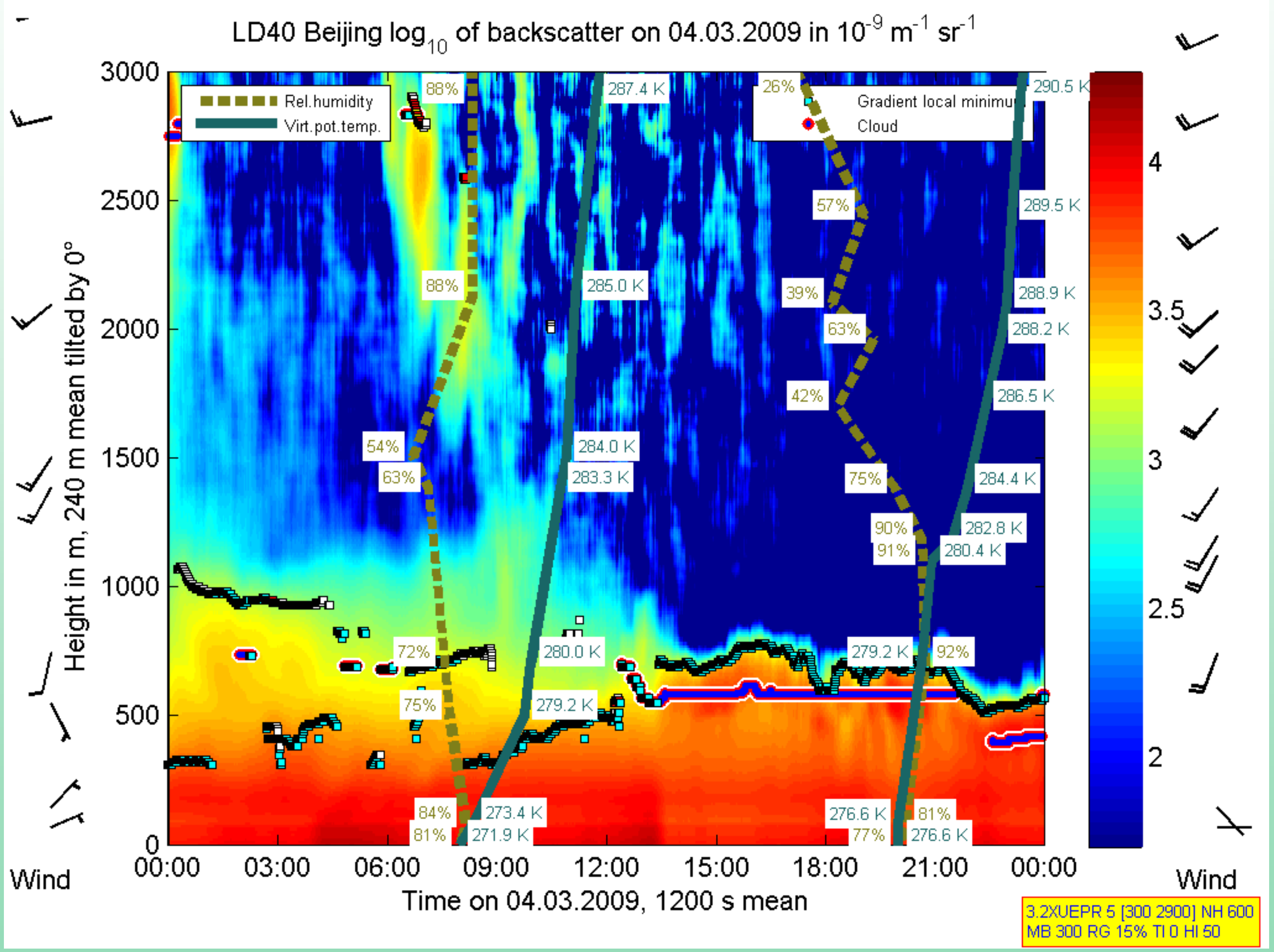
Optical remote sensing:
Ceilometer
Vaisala LD40 or CL31
wave length: 855 or 910 nm
range: 4000 m
Resolution: 10 or 7.5 m



Meteorological monitoring at 325 m LAPC tower

Ceilometer measurements

High particulate load and low mixing layer height



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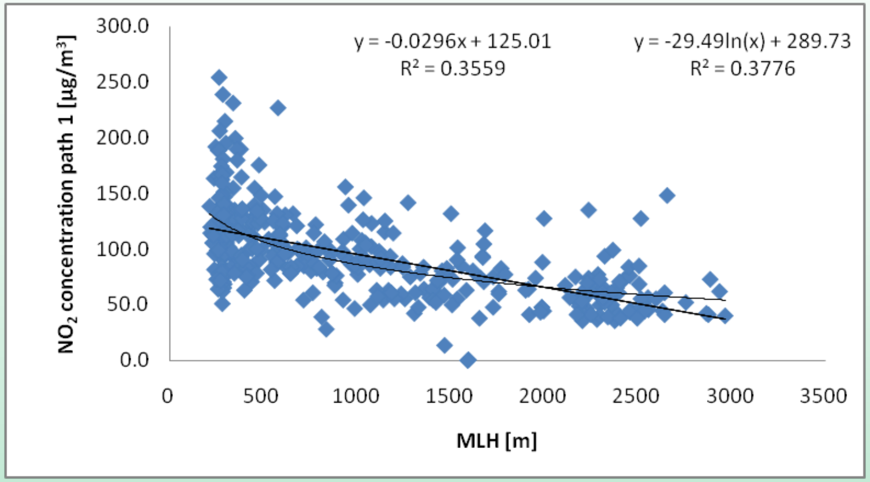
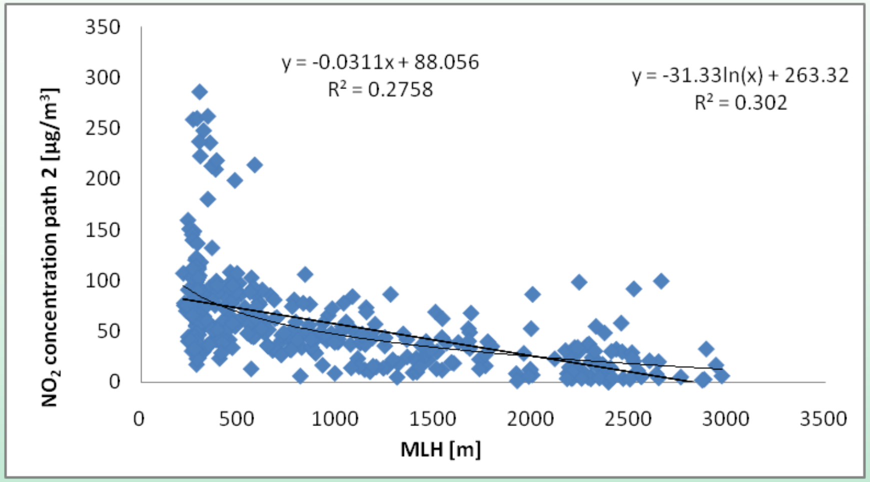
Correlations NO_2 – mixing layer height
April – May 2009

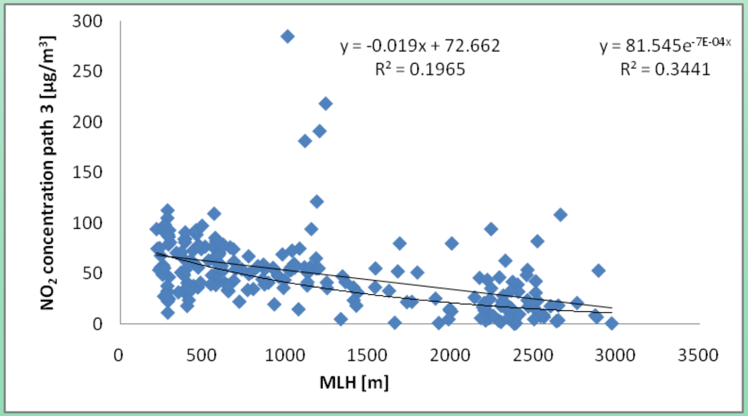
Path 1 across the road nearby



Path 2 in the background



Path 3 across the motorway



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

Logarithmic regression best correlations: NO_2 well mixed
but not at motorway – exponential dependence

Correlations of NO and SO_2 with MLH: not significant

Concentrations of BTX and HCHO: near the detection limit

Further tasks

Tasks for air quality studies in Beijing

Further influences upon air quality

emissions (in the case of NO/NO_2 and SO_2)

air chemistry (photochemistry in the case of NO_2)

by small-scale model studies on the basis of

road traffic data – emission modelling

DOAS together with in situ concentration and meteorological data – transport-chemistry modelling

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Thank you very much for your attention