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Small-scale near-surface HCHO variation in traffic influenced areas

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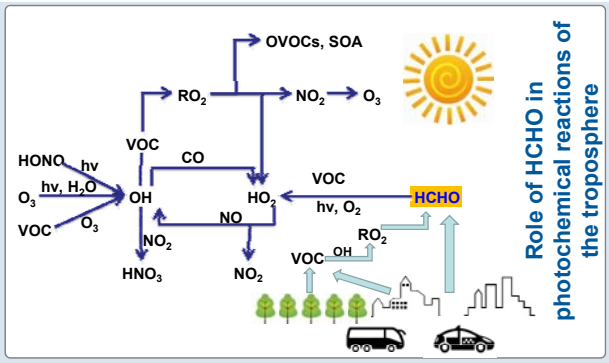
Abstract Formaldehyde (HCHO) plays an important role in photochemical reactions, vegetation-atmosphere exchange processes and adverse health effects as a trace gas in ambient air. Road traffic is an important emission source of HCHO in urban areas. To study HCHO variations in areas with high traffic load , two campaigns were performed by KIT/IMK-IFU in cooperation with IAP-CAS in the cities of Beijing/China and Augsburg/Germany.
Both in Beijing (2009 - 2010) and in Augsburg (2012), near-surface HCHO concentrations were measured by a Differential Optical Absorption Spectroscopy (DOAS) system. Concentrations of NO, NO_2 and O_3 were monitored by both DOAS and in situ instruments. Meteorological parameters like wind direction, wind speed and mixing layer height were obtained from weather stations and ceilometers, which are used for analyzing the influence of local convection and atmospheric stability.
Manual and automatic traffic counting data were analyzed in Augsburg for estimating the influence of on-road vehicle emissions. The diurnal variation of HCHO, NO, NO2 and O3 near-surface concentrations are coupled with meteorological parameters and traffic counting results. The influences of wind, atmospheric stability and local traffic are discussed. Finally, a long-term variation of Beijing near-surface HCHO based on ground-based measurement is discussed.



1. Motivation

- Road traffic → important source of air pollutants
- Formaldehyde (HCHO) is one of the main carbonyl compounds in the near surface atmosphere;
- An important organic air pollutant;
- Plays important role in:
  - o photochemical reactions (precursor of surface O_3)
  - o vegetation-atmosphere exchange processes
  - o human health
- Current observation:
  - o ground-based observation: chemical derivation, PTR-MS, spectroscopy etc..
  - o satellite observation (based on spectroscopy): GOME, GOME-2, SCIAMACHY, etc..

2. Research target

Small-scale near-surface HCHO variation in urban area

- Global scale: a majority of HCHO is from VOCs oxidation;
- Urban area: traffic emissions contribute to a big amount to HCHO concentrations, especially in traffic influenced areas;
- Meteorological parameters, road traffic pattern, surface roughness affect variation of HCHO → temporal and special variation;
- Variation of referenced compounds: O_3, NO, NO_2;
- Use of ground-based HCHO measurement → to verify satellite data.

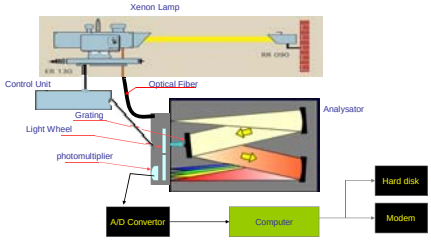
3. Instruments and observation sites

- Instruments: OPSIS UV-DOAS, in situ instruments
- Observation sites:

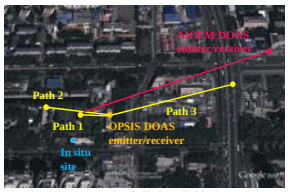
1. Beijing, China: N 39° 58', E 116° 22', located between North Third Ring Road and North Fourth Ring Road, including a motorway in the area;
2. Augsburg, Germany: N 48° 21', E 10° 54', located on Friedbergerstr, including a tunnel exit in the area.

Instruments:

- OPSIS UV-DOAS
- AIOFM DOAS
- UV photometric O_3 analyser (49i, ThermoFisherScientific, Inc. (TE), USA)
- Chemiluminescence-based NO-NO_2-NO_x analyser (42i, TE)

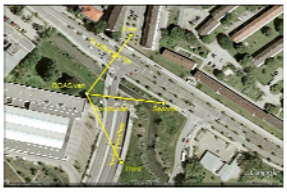


Beijing/China



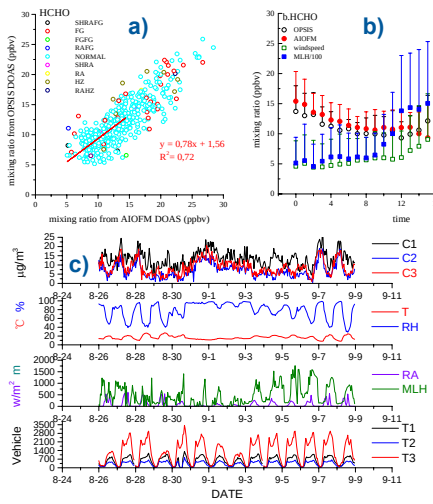
• OPSIS DOAS system was installed in the yard of the State Key Laboratory of Atmospheric Boundary Layer Physics and Atmospheric Chemistry (IAP, CAS) ;
• AIOFM DOAS is a DOAS system built by Key Laboratory of Environmental Optics and Technology, Anhui Institute of Optics and Fine Mechanics (AIOFM, CAS)

Augsburg/Germany



DOAS emitter/receiver unit was set on the roof of a van. The site is close to the main road and the exit of the tunnel.

4. Results: HCHO variation and related parameters



a) Scatter-plots from two DOAS light-paths in Beijing. Mixing ratio level of near-surface HCHO in Beijing is from 5 to 25 ppbv

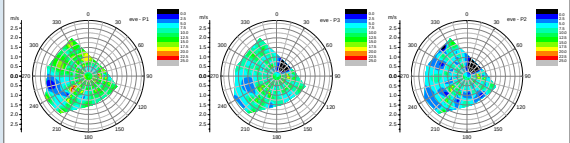
a) Diurnal variation of HCHO mixing ratio, mixing layer height (MLH) and wind speed in Beijing. Maximum value of HCHO mixing ratio appeared at night (20:00 – 21:00);

c) Augsburg: time series of near-surface HCHO concentration, meteorological parameters and vehicle amount.

d) Augsburg: diurnal variation of traffic, surface HCHO and other compounds (O_3 and NO_x)

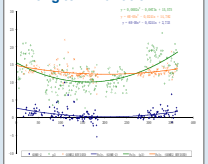
b) The influence of wind

Augsburg, 201206-09, night time



Wind and HCHO concentration distribution on three light-paths in Augsburg (night time from June until September, 2012).

Long term variation



2009.07.01 – 2010.06.30, Beijing ground-based: DOAS observation, satellite data: GOME-2

5. Future Perspectives

- Flux footprint will be applied to better explain the influence of emissions.
- The relationships between HCHO and referenced compounds (O_3, NO_x, hydrocarbon, etc..) will be comprehensively analyzed for a better understanding of HCHO photochemical reaction mechanism.
- Data interpretation to apply in a small-scale dispersion model.
- Ongoing development of the algorithm of conversion of the VCD satellite data into near surface concentration to get long-term HCHO variations in urban areas.
- Improvement of satellite data validation.

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