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Determination of nitrogen dioxide distributions in urban areas with a mobile CE- DOAS instrument

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Today nitrogen dioxide (NO_2) emissions still remain one of the most problematic pollution in urban areas not only in developing, but also in industrialised countries. Also if a lot of effort has already been made towards their reduction, concentrations are often above the recommended limits. For example many European cities do currently not fulfil the EU criteria valid since 2010 which is defined as maximum of 105ppb and 20ppb for the annual average concentration.
Additionally it is known that the NO_2 concentration in urban areas has a strong spatial and temporal variability, due to the large number of NO_x emitting point sources (mainly traffic) that can be found in densely populated areas. However, the air monitoring networks in most urban areas, installed to continuously monitor the officially prescribed NO_2 limits, do not respect the spatial variations because they only conduct measurements at a single or few selected sampling points. Hence, it can be assumed that there are areas with much higher pollution compared to the values at the official measuring sites. To improve the air quality better knowledge of the sources and the concentration distribution are required. An other point is that the typically applied NO_2 instrument are inaccurate due to strong cross correlation to other NO_x components and require regular calibrations.
We present a new instrument for the direct determination of NO_2 concentrations. It combines the well established Differential Optical Absorption Spectroscopy (DOAS) method with a cavity formed by two high reflective mirrors to achieve the required long optical light path (>1km) in a compact setup of 60cm. This so called NO_2 Cavity Enhanced (CE) -DOAS instrument is distinguished by its compact and robust setup with a simple calibration. It is shown that it measures precisely the NO_2 concentration at all realistic conditions. Detection limits of < 0.5ppb are achieved with sampling time of 30s. With higher temporal resolution of 2s still a detection limit of 2ppb is achieved sufficient for urban air monitoring.
Due to the robust setup with low power consumption this instrument is perfectly suited for mobile applications in order to determine the spatial distribution of the NO_2 concentrations. We present several measurements were we applied this setup to measurements in a van in different urban areas. The van travels along carefully selected tracks to give a representative coverage of the area of interest. The mobile measurements are corrected for the varying meteorological conditions and traffic variations during the different measurements by comparing them to a fixed measurement of NO_2. This is best done by a simultaneously performed Long Path DOAS measurement which gives the average NO_2 concentration along a few kilometer long light path over the area of interest.
We will present results from such mobile measurements in Mannheim and Düsseldorf (Germany) and also from Hong Kong. They clearly show that NO_2 concentrations vary in urban areas by more than an order of magnitude on scales of only few 100m. This clearly shows that the environmental measurement stations with their fixed point measurements do not sufficiently capture these variations and the given results may not be correct for a location close by. This may not only have a significant influence for health aspects, but also have a significant influence on chemical model calculations.
The instrument will be further developed to be applied in Unmanned Aircrafts.