Quantifying the contribution of individual vehicles to NO$_2$ pollution in an urban area

Denis Pöhler (1), Florian Kanatschnig (1), Martin Horbanski (1), Axel Friedrich (2), Johannes Lampel (1,3), and Ulrich Platt (1)

(1) University of Heidelberg, Institute of Environmental Physics, Heidelberg, Germany (denis.poehler@iup.uni-heidelberg.de), (2) International Transport Adviser, Berlin, (3) now at Max-Planck Institute for Chemistry (MPIC), Mainz, Germany

Nitrogen Dioxide (NO$_x$) emissions by road vehicles are the mayor contributor for poor air quality in urban areas. High NO$_x$ concentrations, and especially NO$_2$, are typically the most problematic pollutant in mega and other cities. However emissions vary significantly depending on the type of vehicle and its engine, the age and condition of the vehicle, driving properties and many more. Even if data of the manufacturer exists how much NO$_x$ different vehicle types emit, reliable data under real driving conditions are rare and often missing. Especially data showing the degree to which different cars contribute to observed NO$_x$ levels are missing. Significant reduction of NO$_x$ concentrations can be achieved by identifying the strong emitting vehicles and excluding / replacing these. As this is only a small amount of vehicles (typically less than 10% of the vehicles make 90% of the emissions), such a small investment can significantly improve air quality.

In order to perform measurements of NO$_x$ we applied a high speed NO$_2$ CE-DOAS (Cavity-Enhanced DOAS) instrument in a car which was modified for this application. It measured directly the NO$_2$ concentration behind followed vehicles while driving, with a time resolution of 2 s and an accuracy of $\sim$1ppb. Even if such observations depend on many parameters like mixing-in of ambient air, distance, solar radiation, ozone concentration, background concentration etc., it delivers valuable data under real driving conditions.

The instrument was applied in the city of Mainz, Germany to investigate within 7 days (March / April 2014) the NO$_x$ emission of 728 vehicles and to quantify the main emitters. Therefore the measured NO$_2$ concentration in comparison to the background concentrations was quantified. Observed vehicles were separated in 4 categories: cars, busses, trucks, and motorcycles. We observed NO$_2$ levels from a few ppb (within the background variation) up to 7000ppb NO$_2$ above the background level. Strong variations within the same vehicle category could be observed. NO$_2$ levels above 500ppb are found only for 2,2% of all measured vehicles and these are mainly busses (especially older models) but also few cars and motorcycles. On average NO$_2$ concentrations behind the vehicles were 222ppb above background level. This could be reduced by 45% by just excluding the strongest emitters (2,2% of all vehicles). Our study clearly shows which vehicles exhibit the strongest NO$_2$ emissions under real driving conditions and which vehicles contribute most to urban NO$_x$ pollution. It demonstrates how such measurements at high temporal resolution on a mobile platform can give recommendations to policy makers to significantly improve air quality in mega and other cities at moderate cost.

In the future our system will be expanded with a NO and O$_3$ measurement system to quantify all relevant species.