Analysis of the Impacts of an Environmental Traffic Management System on Vehicle Emissions and Air Quality

Lina Neunhäuserer, Volker Diegmann, IVU Umwelt GmbH, 79110 Freiburg, Germany

Introduction

Environmental traffic management systems (ETMS)
- are implemented to improve air quality in urban streets
- allow for a traffic-related control of light signal systems
- optimise road capacities and enhance traffic flow in street sections.

ETMS
- are equipped with mitigation strategies
- are continuously provided with traffic and air quality data.

Assumption:
Improving the traffic flow results in lower vehicle emissions and thus in lower pollutant concentrations, provided that the vehicle intensity does not change.

Task:
- verify this assumption
- quantifiy potential effects

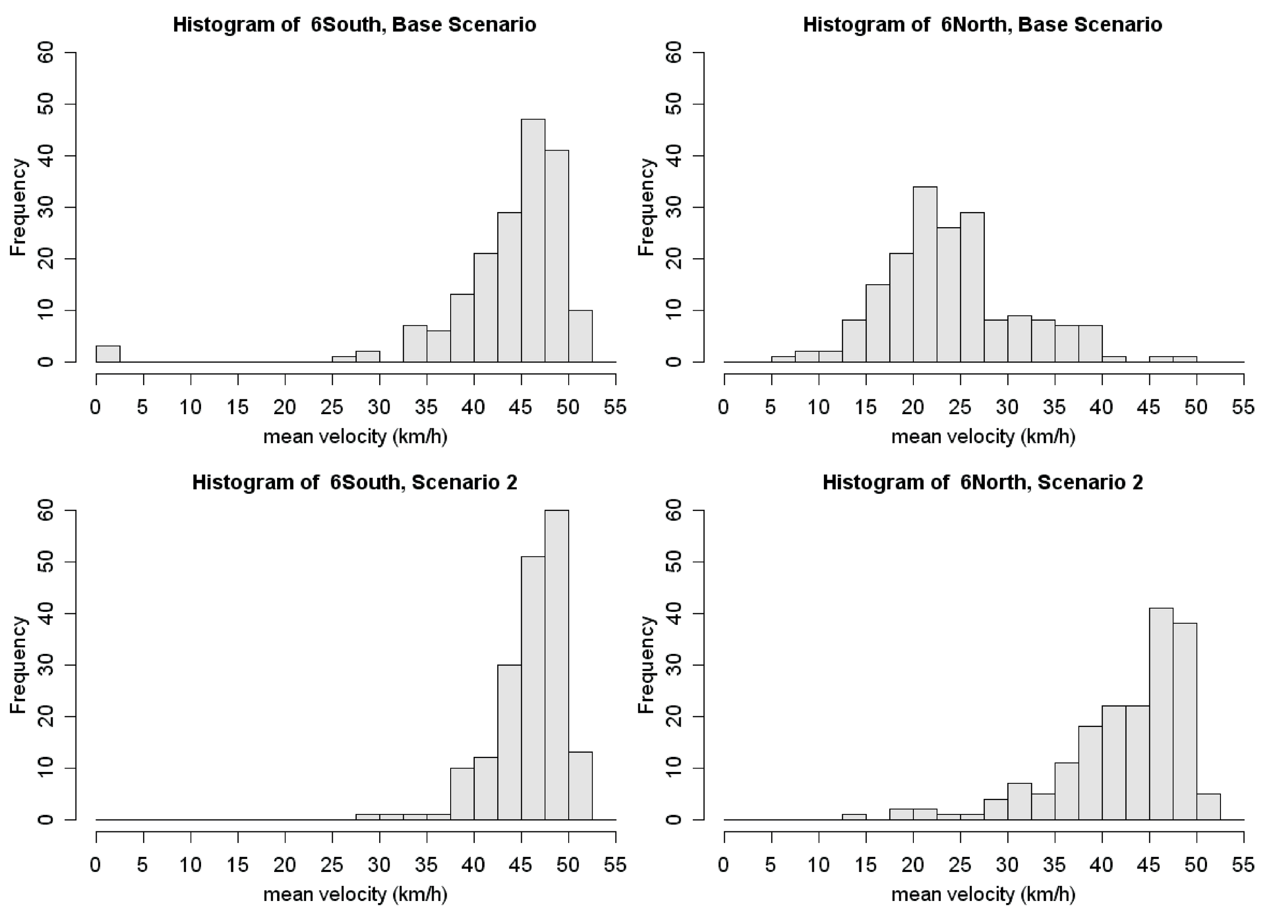
Traffic Data

Traffic data was modelled with the microscopic simulation program VISSIM for each scenario for the hour with maximum traffic load. The traffic data was calculated for the considered road network, divided into 11 street sections with three cross sections each.

VISSIM results:
for each cross section and each direction of traffic, time series of:
fleet composition, vehicle intensity, mean velocity, mean acceleration, congestion data

The VISSIM results were evaluated statistically to gain mean hourly values for each parameter for each street section. Applying the ETMS scenarios
- improves the traffic flow
- increases the mean velocity
- decreases the standard deviation of velocity

for street section 6 where the air quality monitoring station is located.



Histograms of mean velocity, exemplarily for street section 6 at air quality station, Base Scenario (top) and Scenario 2 (bottom).

Conclusions

- The ETMS scenarios 1-3 improve the traffic flow at the hot spot Clevischer Ring.
- Enhancing the traffic flow results in a significant decrease of traffic emissions at the hot spot as well as for the considered street sections in total.
- Scenario 1 leads to a significant decrease of the additional pollutant load within the investigation area and thus improves the air quality situation. Scenario 2 improves the situation further. For Scenario 3, concentrations decrease only in some parts of the investigation area compared with Scenario 2.
- The significantly improved air quality situation at the monitoring station Clevischer Ring for the ETMS scenarios goes along with minor increases of the additional pollutant load in non-critical areas.
- Based on the dispersion modelling results and a theoretical approach, the potential of Scenario 2 to reduce the NO_2 annual mean concentration at the monitoring station Clevischer Ring was assessed to be 6 % to 9 % for 2008.
- ETMS may be a worthwhile measure to improve the air quality in heavily trafficked areas. The effect on the surrounding road network should be considered carefully to avoid inducing new hot spots by eliminating existing ones.

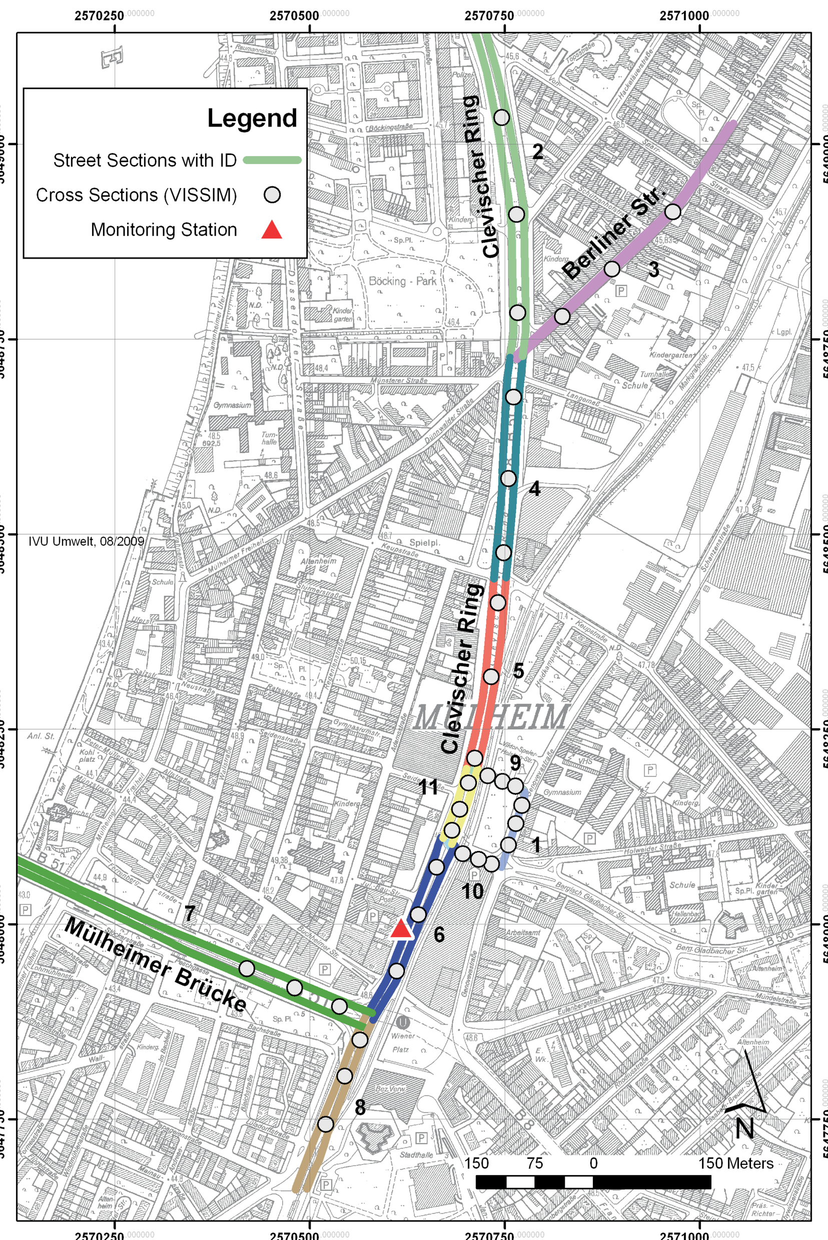
Acknowledgements
These results are an outcome of the joint project "Umweltsensitives Verkehrsmanagement Stadt Köln". Project partners are IVU Umwelt GmbH, SIEMENS AG and Stadt Köln.

Test Case Clevischer Ring

The Cologne clean air plan 2006 reports NO_2 limit value exceedances at several monitoring stations. A low emission zone has been established for Cologne on January 1st, 2008, as a first step to improve air quality. Additionally, it is planned to install an ETMS for two heavily trafficked areas of Cologne.

One of the two areas, Clevischer Ring in Cologne-Mülheim, was chosen as a test case. Modelling was carried out in advance to assess the impacts of the ETMS on traffic-induced emissions and air quality. An air quality monitoring station is located in Clevischer Ring. Four traffic scenarios were modelled, a base scenario and three ETMS scenarios:

- Base Scenario: typical hour with maximum traffic load
- Scenario 1: improved, traffic-dependent control and coordination of light signal systems
- Scenario 2: scenario 1 plus gatekeeping at the southern, northern and western inlet
- Scenario 3: scenario 2 plus restriction of existing public transport priority



Modelled road network Clevischer Ring with street sections and cross sections.

Modelling

Modelling was carried out in four steps:

- Traffic data for the four scenarios was calculated.
- Emissions for the hour with maximum traffic load were determined.
- Dispersion of the pollutants within the investigation area was modelled, using meteorological data for which the maximum additional pollutant load was to be expected.
- Decrease of the pollutant annual mean concentrations at the monitoring station was assessed, based on dispersion modelling results.

Emission Data

Emission data was modelled with IMMIS$^{em/micro}$ for each scenario for the hour with maximum traffic load. IMMIS$^{em/micro}$ uses a linear combination of driving patterns defined in HBEFA to derive traffic situations and emission factors for the calculated traffic data.

The calculated emissions depend on

- the chosen driving patterns
- the stop & go-fraction
- the vehicle intensity
- the fractions of heavy and light duty vehicles and busses.

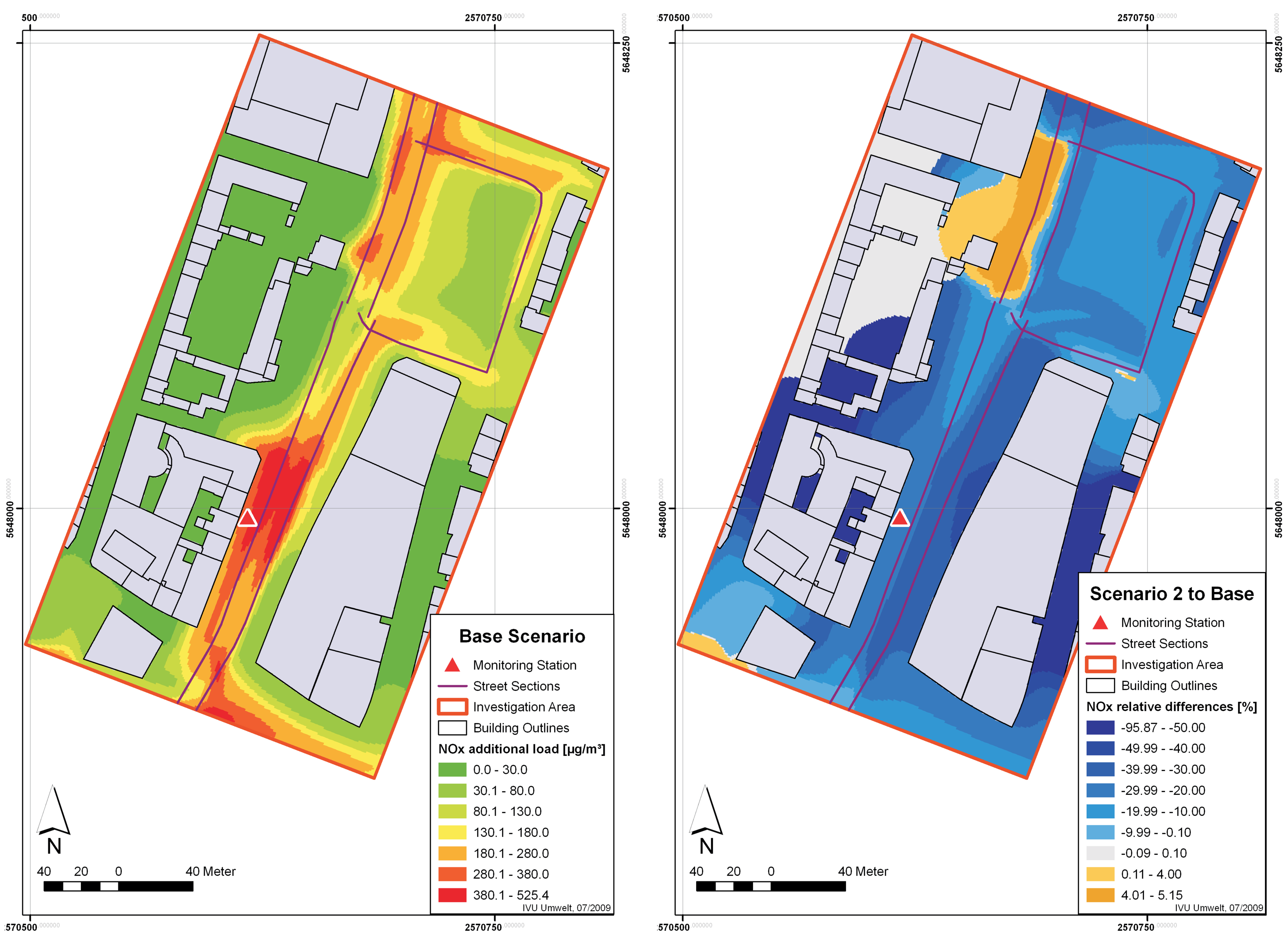
The NO_x emissions of Scenario 1 - 3 decrease significantly for most of the northbound street sections of Clevischer Ring. Lower emissions are also found for 2South, 4South and 9West.

For street section 7East, emissions decrease for Scenario 1 and increase for Scenario 2 and 3. This is due to the gatekeeping function of 7East in the latter scenarios which leads to larger stop & go-fractions, lower mean velocities and less advantageous driving patterns. Increased emissions are also observed for 7West, 8South, 10East and 11 South.

Generally, NO_x emissions increase by at most 18 % while they decrease by up to 45 %.

Absolute values (top) and relative differences (bottom) of NO_x emissions of Scenarios 1 - 3 compared to Base Scenario for all street sections.

Dispersion Modelling and Assessing Annual Mean Concentrations



Left: NO_x additional pollutant load due to traffic emissions under critical wind direction 270° for Clevischer Ring at level 1.3m - 2.0m. Right: Relative differences of NO_x additional pollutant load.

Dispersion modelling was carried out with MISKAM 5.02. The investigation area contains the location of the air quality monitoring station and several street sections of Clevischer Ring. The critical wind direction for maximum additional pollutant load was identified to be 270°.

For the Base Scenario, NO_x additional pollutant load reaches its maximum in the street canyon, close to the air quality station. North of the building block, concentrations decrease due to improved ventilation.

Relative differences of Scenario 2 and Base Scenario show a drop of concentration of up to 40 % within the street canyon area. Slight increases up to 5 % are observed for some other parts of the investigation area.

These results are valid for an hour with maximum emissions under unfavourable meteorological conditions. The impact of Scenario 2 on the annual mean value 2008 was assessed by assuming that Scenario 2 was implemented as a temporary measure, actived as soon as the NO_2 hourly mean concentration at the monitoring station Clevischer Ring reached:
A: 60 µg/m³, B: 70 µg/m³, C: 80 µg/m³.

The results are given in the table to the left.

Results for Scenario 2 implemented as a temporary measure.

Case	A: 60 µg/m³	B: 70 µg/m³	C: 80 µg/m³
fraction of time with activated measure	45 %	36 %	26 %
potential reduction of NO_2 annual average	9.0 %	7.8 %	6.1 %