A Monitoring System to Control Effects and Effectiveness of Traffic Measures in Urban Areas

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Introduction and Motivation

Application

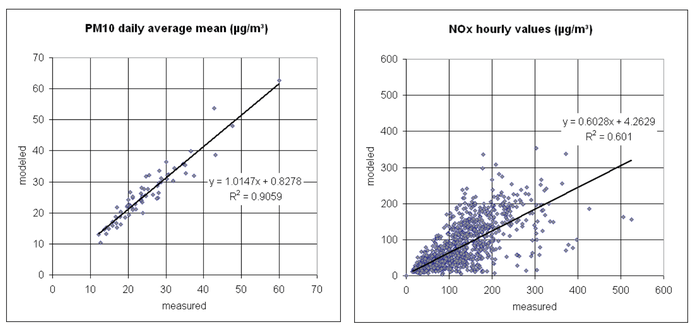
Installation of a monitoring system in Braunschweig, Germany

- as part of an environmental traffic management system (ETMS)
- within a project on environmental traffic management ("UVM Umweltorientiertes Verkehrsmanagement Braunschweig")

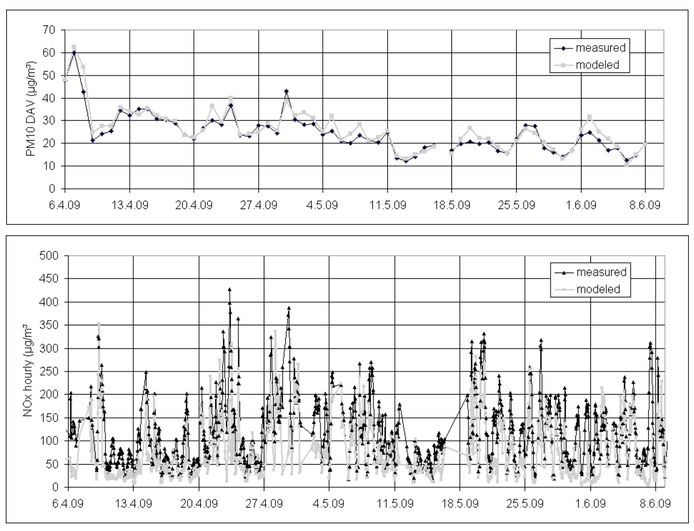
Tasks

- modelling two scenarios based on traffic data without any measures and with reduced traffic using identical input data otherwise
- assessing the effectiveness of implemented traffic measures for a selected hot spot as well as the side effects

Validation



Scatterplot and regression analysis of modeled vs. measured data for PM10 daily mean and NO_x hourly values



Time series of modeled and measured PM10 daily mean values (top) and NO_x hourly values (bottom)

Comparison of average values for measured and modeled PM10 and NO_x

Substance	Period	ID	Measurement (µg/m³)	Model result (µg/m³)	Deviation (Mod-Meas)/Meas
PM10	06.04. - 10.05.	test phase 1	29.3	31.2	6.6 %
	11.05. - 09.06.	test phase 2	18.7	19.7	5.4 %
	01.04. - 09.06.	test phase 1+2	24.7	26.1	5.6 %
NO_X	06.04. - 10.05.	test phase 1	117.9	77.2	-34.5 %
	11.05. - 09.06.	test phase 2	117.1	76.3	-34.9 %
	01.04. - 09.06.	test phase 1+2	117.2	76.1	-35.1 %

Modelling results from IMMIS^{mt} were validated with the measured data from the monitoring station at the hot spot in Altewiekring.

PM10

- modeled time series of PM10 daily mean values are in overall good agreement
- corresponding coefficient of determination calculates to very good 91%
- hot spot PM10 concentration is mainly influenced by the regional background concentration which is not part of the modeling procedure

NO_X

- modeled time series of NO_X hourly values agree partly very well with measured values
- overall characteristics of the measured time series is met by the model as well
- the model often underestimates maximum concentration values
- coefficient of determination is 60% which is low compared to the PM10 result
- possible reasons:
  the larger fraction of urban background and additional pollutant load, both part of the modeling procedure
  short averaging period (an hour for NO_X compared to a day for PM10) because of less variability associated with longer averaging periods

Values averaged over test phase

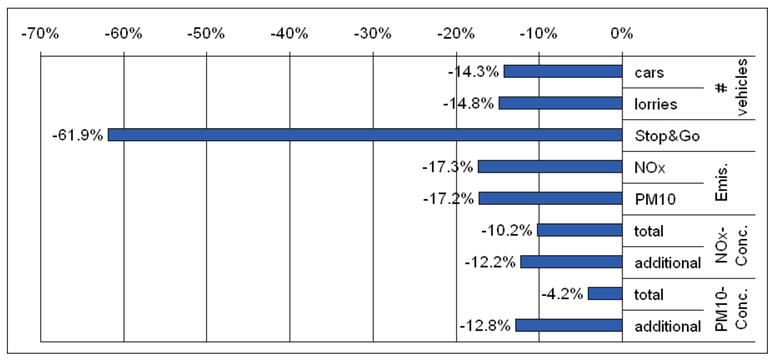
- PM10 overestimated by 5% to 7%
- NO_X underestimated by up to 35%
- NO_X underestimation of the modeled data may be attributed to a large degree to the emission factors of HBEFA 2.1

Results

Effectiviness of Measures

The figure to the right shows the effects of the traffic measures implemented for Altewiekring at the hot spot site:

- vehicle intensity was reduced by 14%
- traffic-induced emissions were reduced by 17%
- disproportionate decrease due to improved traffic flow with less stop&go-situations
- reduction of the additional pollutant load by 13% (PM10) and 12% (NO_X)
- decrease of total concentrations by 4% (PM10) and 10% (NO_X)

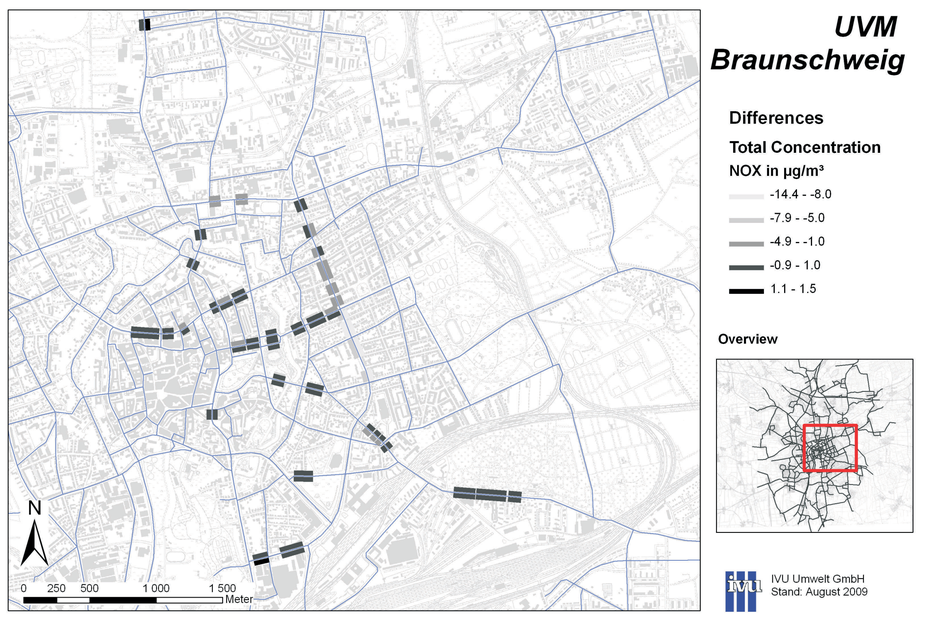


Effects of implemented measures on traffic load, traffic-induced emissions and pollutant load

Controlling of Side Effects

The figure below shows the differences of NO_X total concentration in the monitored street sections

- differences result from implementing traffic measures for the hot spot site Altewiekring
- differences are calculated from modeling results for test phase 2 and from results for modeling test phase 2 with the traffic data replaced with data for the same period in the previous year when no traffic measures were applied
- NO_X total concentration decreases by up to 14.4 $\mu g/m^3$ and increases by up to 1.5 $\mu g/m^3$
- relative differences between NO_X total concentration with and without traffic measures vary between a reduction of 16% and an increase of 6%
- PM10 total concentration decreases by up to 2.2 $\mu g/m^3$ and increases by up to 0.3 $\mu g/m^3$
- relative differences of PM10 additional pollutant load due to traffic decrease by up to 16% and increase by up to 20%



Effects of implemented measures on NO_X total concentration in street sections

Conclusions

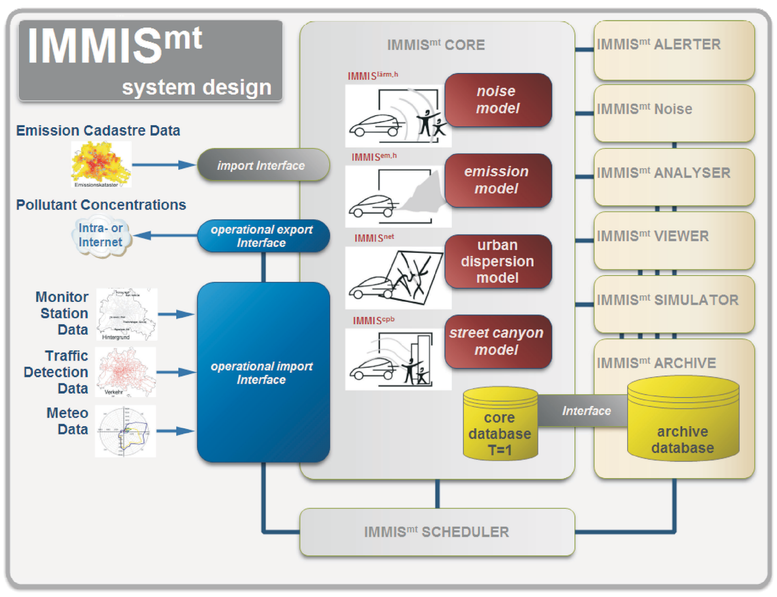
The results emphasise the importance of a monitoring system offering the possibility to assess and control the consequences of traffic measures within the entire road network.

A monitoring system offers the possibility to validate the implemented models and their input data, e.g. the database of emission factors HBEFA.

Acknowledgements

This paper is an outcome of the joint project "UVM Umweltorientiertes Verkehrsmanagement Braunschweig". Project partners are BELLIS GmbH (Braunschweig), BLIC GmbH (Braunschweig), IVU Umwelt GmbH (Freiburg) and VMZ Berlin Betreibergesellschaft mbH. The project was founded by the German Federal Ministry of Transport, Building and Urban Development and supported by the Federal State of Lower Saxony and the City of Braunschweig.

Monitoring System



The environmental monitoring system installed in Braunschweig is an implementation of IMMIS^{mt}. The core of IMMIS^{mt} consists of three models, forming a modeling chain to calculate traffic-induced emissions, urban and local dispersion. Based on incoming traffic data, emissions of the major roads are determined with the emission model IMMIS^{em}. Together with emissions of other urban sources, the citywide spatial distribution of air pollutants is calculated using the urban dispersion model IMMIS^{net}. This provides the urban background concentration for each section and for the locations of air quality monitoring stations. The regional background can then be determined as difference between the observed concentration at the background station and the urban concentration modeled for the station. Finally, the micro scale model IMMIS^{cpb} is applied to assess the additional concentration due to traffic within each street canyon with the Canyon Plume Box approach using meteorological and local emission data. To derive NO_2 values from the calculated NO_X concentrations, IMMIS^{mt} provides different methods ranging from simple statistical techniques based on measurements to photochemical models.

The data flow between the models is coordinated by software components controlling the temporal sequence of the overall system, which includes data supply, start of the models, data transmission to the archive and data export of the results to further clients (e. g. map clients). All input and output data is passed through adjustable interfaces that are capable of controlling various data transmission techniques (e. g. SOAP). The internal data storage structure is realized with a local or a client-server database (e. g. Oracle) storing all static data as well as all dynamic data for the current modeling interval. The system's archive is based on a client/server database and stores the total input and output data of all computations. With the simulator module, the stored computations can be repeated - if desired with changed conditions. This allows for the analysis of scenarios.

Internet presentation of modeling results