MODELLING OF STREET CANYONS – VALIDATION STUDY WITH THE DATA PROVIDED FOR THE STREET EMISSION CEILINGS EXERCISE

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INTRODUCTION

Since traffic is the dominating source of pollution in most cities, the street canyon environment has been pointed out to show the quality of modern micro-scale modelling methods. Regarding the dispersion of pollutants in street canyons, calculated concentrations obtained by numerical models are validated with the dataset provided for the Street Emission Ceilings (SEC, http://aix.meng.auth.gr/sec/) project.

For the SEC exercise detailed data has been made available for highly frequented street canyons in three European cities (Stockholm, London, Berlin) including measured street-level and background concentrations of pollutants as well as meteorological time series and car emission rates.

In Stockholm – in the Hornsgatan street – two monitoring stations have been operated (*Gidhagen L. et al., 2004)* on opposite sides of the canyon a few meters from the facades. These datasets are used in this study to investigate the influence of the dominant meteorological conditions on the local distribution of pollutants.

The up to date dispersion models ADMS-Roads and LASAT are used for the calculations. ADMS-Roads is a gaussian model and uses the parameterised flow of its street canyon module for the simulation while LASAT as lagrangian model includes a 3D windfield model. Both models used the same input-data and settings and were run by one person.

DESCRIPTION OF THE MONITORING SITE

The Hornsgatan street canyon is situated in the south of Stockholm and extends over several kilometres in the east-west direction. It has a width of about 24 m and is lined with buildings on each side that are 24 m high. The traffic volume is on average about 35000 vehicles per day (weekdays) with a fraction of 5% of heavy duty vehicles.

NO_x is measured on both sides of the street at about 1.5 m distance from the buildings, in 3 m above ground. The datasets include hourly measurements for the year 2002. The background concentrations of NO_x were measured at roof level near the street canyon at Rosenlundsgatan.

Wind-speed and wind-direction were measured at a 10m mast above roof level 500 m from the street canyon. Temperature was obtained from the meteorological tower in Stockholm.

The modelling domain comprises a 500 m section of the street including neighbouring streets and buildings to account for the complex flow situations that can be modelled with LASAT. Figure 1 shows a map of the modelling domain and the location of the stations. The approximate angle of the street to the north direction is 77°.

Fig. 20; Modelling domain of the Hornsgatan street in Stockholm. The circles mark the monitoring station on the north- and south side of the street.

APPLIED MODELLS

ADMS ROADS (*Mchugh,1997*) is based on a gaussian approach and includes a street canyon module. The model assumes a straight length of the road with a constant width and is lined continuously by flat roofed buildings of a specific height. Effects like junctions can not be modelled. If there is a wind component normal to the canyon, a vertical vortex on the lee side is build. The extend depends on the wind speed and direction above the canyon.

LASAT (*Janicke, 2003*) is a lagrangian particle model and has a diagnostic windfield model integrated in the meteorological preprocessor that allows to consider modifications of the flow field by terrain and buildings. These can have various heights and complex geometry.

RESULTS AND DISCUSSION

The windrose in Figure 2 shows the wind distribution at the modelling site. The most frequent wind directions lie between 180 and 270 degrees with wind speeds between 3 m/s and 5 m/s.

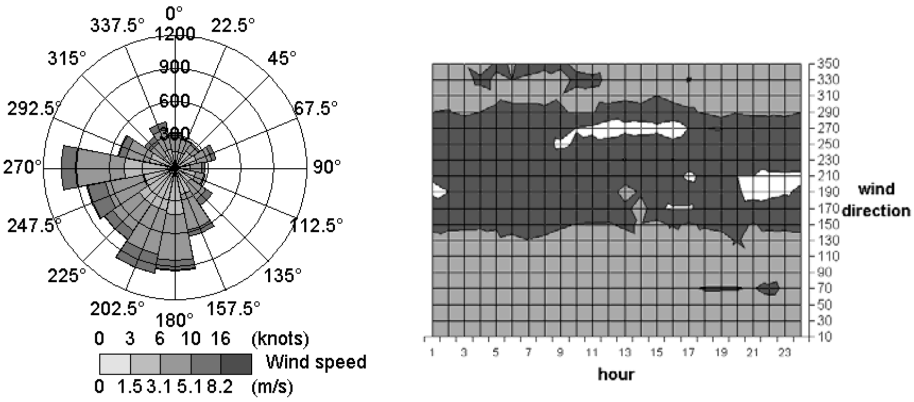

Fig. 2; Windrose and hourly frequency for year 2002 , Hornsgatan.

The wind direction frequency over the whole year at the specific hours of the day shows few variation in the daily pattern. That means that the main wind directions are between nearly street parallel (west) and nearly wind normal to the street (south) at every hour of the day.

The differences between the observed and calculated NO_x concentrations for the northern and the southern monitoring site are plotted for different wind directions in Figure 3. The difference is positive if the concentrations at the northern point are higher than at the southern point and vice versa.

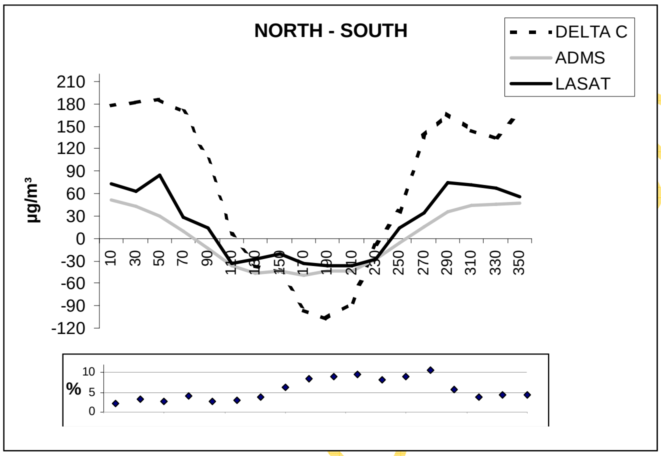

Fig.3; Differences between calculated north- and southside NO_x concentrations compared to the measurements. The wind direction frequency (%) is shown at the bottom. The concentrations are averaged for wind sectors of 20°.

The measurements show that for wind directions between 110° and 230° the concentrations at the southern side are higher than those at the north. It can also be assumed that the emissionrates at the northern side are higher than on the lanes in the south because the cars that are heading to the west direction have to run up a slope of about 2.3 % and therefore pass the monitoring station under acceleration. The cars driving in the other direction are running downhill. In these calculations the influence of the slope is not included in the modelruns.

This effect can be found in less extend in the results of the model LASAT. The results calculated show that the absolute values at the northern side are higher than those at the south even for flow directions parallel to the street (~ 77° and 257°).

The curve calculated with ADMS Roads is symmetric around street parallel flows because of the simplified approach of the model which uses only a straight canyon with no crossing roads. For certain wind directions ADMS Roads calculates higher concentrations on the south side while the observed and the concentrations obtained by LASAT are already higher on the north side.

Figure 4 shows the average daily patterns for the two monitoring stations in comparison with the model calculations.

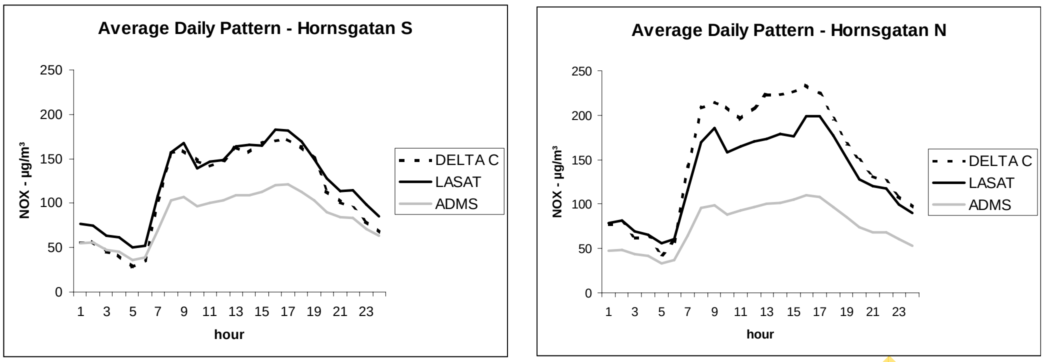

Fig.4; Average daily pattern of NO_x concentrations for the north- and southside of the street canyon compared to measurements.

The concentrations calculated with LASAT for the south side are in good agreement with the monitored data during the day when there is a high traffic flow. Only in the morning and evening hours there is a slight overestimation. ADMS Roads results fit well in the morning till 7 pm but then underestimate the measurements during daytime when traffic is high (average daily patterns of emission rates are used).

At the northern side, LASAT results are close to the observed concentrations in the morning. Between 9 am and 18 pm, the measurement data is underestimated by the model by about 50 µg/m³. A possible explanation could be the slope of the street which is not modelled here. Higher emission factors for the northern lane could improve the results. ADMS renders very low concentrations for this site which is probably because of the simplified approach for flow parameterization. This does not reproduce the asymmetric concentration distribution considering the different wind directions mentioned above

CONCLUSIONS

Observed NO_x datasets on each side of a busy street canyon are used to make comparisons between two dispersion models. The models show certain characteristics for different flow directions depending on the approaches used to consider flow modification by buildings. The impact on the average daily NO_x distribution in the street canyon is investigated. LASAT reproduces the measurements very well except during day-time on the northern side. ADMS Roads underestimates the NO_x concentration on both sides of the canyon. The possible influence of the slope on the traffic emissions has still to be investigated.

ACKNOLEDGEMENTS

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