2.07 PROBLEMS, EXPERIENCED WHEN MODELLING HOURLY CONCENTRATION VALUES IN STREET CANYONS

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INTRODUCTION

Operational modelling of air pollutant concentrations with high temporal resolution, say hourly values in street canyons in the frame of assessments according to EC Air Quality Directives 1999/30/EC and 2000/69/EC, shows to be problematic. On one hand presently existing models are well established, even in case they work on the basis of time series, but on the other hand they usually are only validated for the calculation of annual-mean values and percentiles, say 98-percentiles. Large deviations between measurements and single calculated hourly values can be observed. It is the purpose of the presentation not to give a systematic overview over the performance of modelling tools but to show some details and point out some problems when calculating for example the 18th highest hourly value for NO_2, which is limited in 1999/30/EC. This will be demonstrated on the basis of our experience with 2 street canyons, Reinhold-Frank-Strasse, Karlsruhe and Goettinger Strasse, Hanover.

STREET CANYON REINHOLD-FRANK-STRASSE, KARLSRUHE

For UMEG, Zentrum fuer Umweltmessungen, Umwelterhebungen und Geraetesicherheit, Karlsruhe, a study was executed for the street canyon Reinhold-Frank-Strasse in Karlsruhe to compare for 3 episodes (each consisting of 3 days) hourly calculated concentrations of NO, NO_x and NO_2 to concentrations, monitored by UMEG.

UMEG provided the meteorological data for the calculations, that were taken from a monitoring station about 5 km away from the street canyon and provided the hourly NO_x emission inventory (for all relevant 6 classes of emissions) for a region of 30 km by 30 km surrounding Reinhold-Frank-Strasse, including the NO_x emissions in the street canyon calculated on the basis of former traffic counts and a standardized distribution of the traffic volume within a day. Additionally the concentration time series of the 6 air pollutant monitoring stations within a radius of 15 km were provided.

The hourly background (above roof) concentrations in Reinhold-Frank-Strasse were calculated by use of a Lagrangian flow and dispersion model (LASAT), applied on the basis of the topography and land use in the area under consideration (30 km by 30 km). The emission time series are taken from the emission inventories, and the meteorological data are given at a reference point. The area of Reinhold-Frank-Strasse was nested inside that area. The contribution of concentration of Reinhold-Frank-Strasse was calculated on the basis of the provided hourly emissions and meteorological data and the local building configurations using the microscale flow and dispersion model WinMISKAM, described in Lohmeyer et al. (2002). WinMISKAM covered an area with a horizontal extension of 425 m by 600 m. The grid size was 2 m near the monitoring station increasing to 20 m at the edge of the modelled area. The NO_x to NO_2 conversion was calculated according to the scheme of Romberg et al. (1996), not because the authors believe that this is a reliable method to apply for such cases but because as in many other operational studies, there was a lack of data to apply more sophisticated conversion models. Figure 1 displays the comparison of calculated and monitored concentrations for NO_x and NO_2.

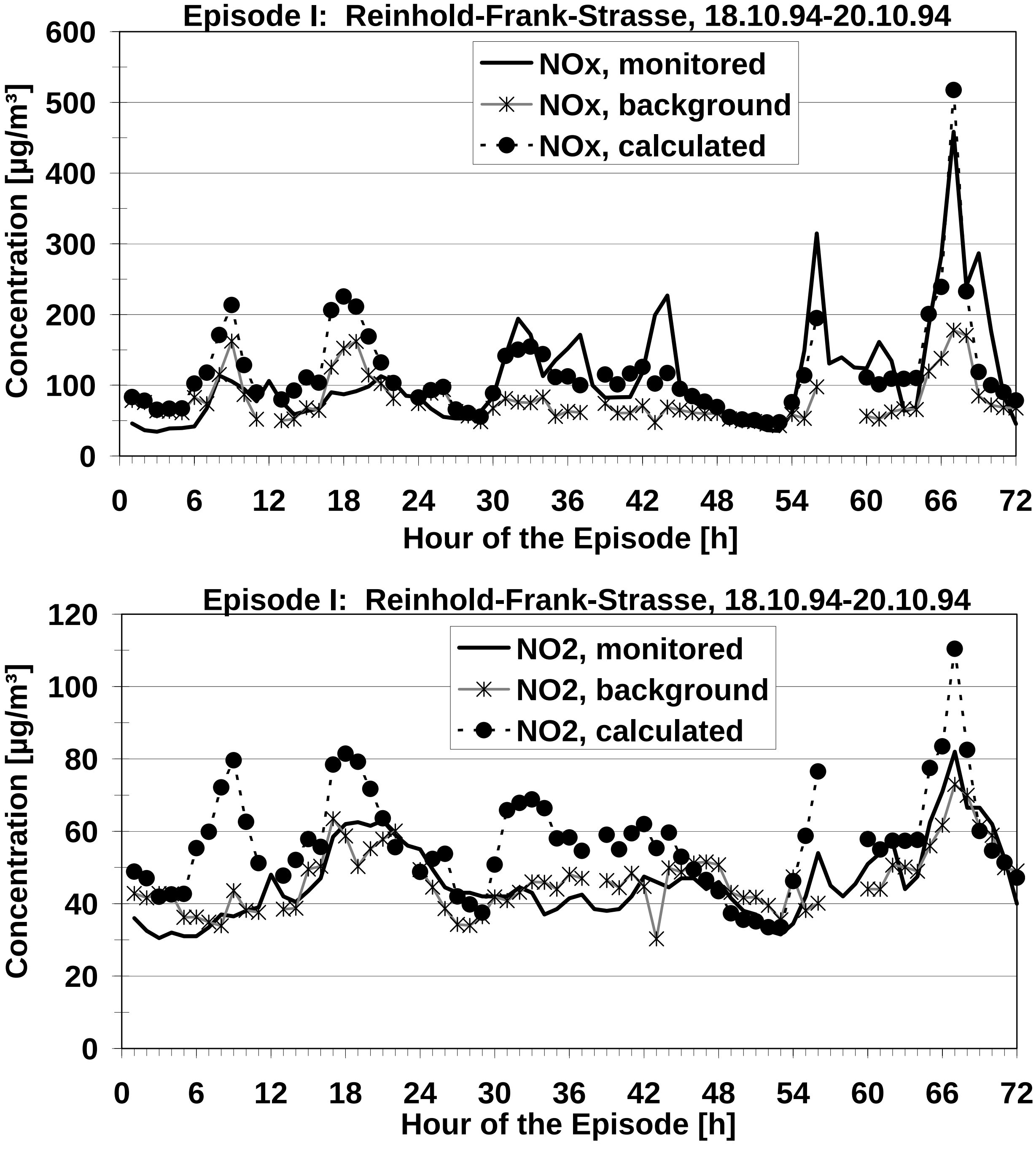

Figure 1. Comparison of monitored (in street canyon), calculated background and calculated (in street canyon) NO_x and NO_2 concentrations for Episode 1.

The overall comparison of the monitored and calculated concentrations in figure 1 might not be too bad at first glance when looking for the mean values over the episode. Also the effects of the rush hours seem to show up, but serious deficits can be detected when comparing details. For NO_x for example at hour 18 the calculated concentration is about double the value of the monitored concentration and the calculated background concentration is higher than the monitored concentration in the street canyon, whereas at hour 44, the background concentration correctly shows lower than the monitored street canyon concentration, but the measured is twice the calculated concentration. For NO_2 the calculated concentrations consistently are higher than the monitored ones, whereas a similarity in the time series of the calculated and monitored concentrations can be seen.

Thus it can be concluded for this case, that either the input data are deficient, and/or that the models applied do not work satisfactorily although proven to work successfully for the determination of the statistical parameters of yearly concentration time series as annual mean and 98-percentile.

Concerning shortcomings in the input data, the hourly values of the emissions have to be addressed. They are based on a standardized distribution of the traffic within a day. That might be acceptable when calculating annual means or even 98-percentiles. A 98-perzentil represents the 175th highest hourly value of a year. Thus 2 hours traffic jam per week or the traffic induced by the 24 major events in the local sports arena might not influence the 98-percentile, i.e. the 175th highest hourly concentration value, but for the 18th highest value to apply EC Air Quality Directive 1999/30/EC or to the prediction of hourly values for the information of citizens or sophisticated traffic management detailed traffic data must be provided. Additionally the availability of the background concentration time series showed to be a problem. As usual, local above roof of the street canyon concentration measurements were not available. But although – for operational standards – sophisticated input data and a sophisticated model were provided, for several hours the background concentration was calculated to be higher than the concentration in the street canyon.

Concerning shortcomings in the models applied, the NO-NO_2 conversion is one important point. The scheme applied is a simple regression model, based on the results of field measurements, describing the conversion rate as a function of the NO_x concentration only (Romberg et al., 1996). The scheme explicitly was developed and only works for annual means and 98-percentiles but not for single hours. It was applied nevertheless because no input data were available to use more sophisticated conversion models, as they are for example included in the model OSPM (Berkowicz, R., 2000).

STREET CANYON GOETTINGER STRASSE IN HANOVER

Analogously to the investigation in Reinhold-Frank-Strasse, comparisons were made for Goettinger Strasse, Hannover with the difference, that detailed traffic information and the above roof concentrations and meteorological data were available (Bächlin et al., 2003). These detailed validation measurements indicate, that at least the traffic produced turbulence is a very important parameter which needs to be included into the modelling of hourly concentration values. This is known to hold true especially for low wind speeds (Ketzel et al., 1999), but even for wind speeds well above the annual mean it is important. See figure 2 from Bächlin et al.(2004).

Additional street canyon concentration c in figure 2 means concentration monitored in street canyon minus above roof concentration. Triangels represent the monitored values. The circles describe a reciprocal dependance fitted to the concentrations for the highest wind speeds. As can be seen from the right figure, for low traffic volume the concentration follows the 1/u dependance, but for high traffic volume (left figure) it does not. It even seems from this figure, that the threshold wind speed above which the 1/u dependance holds true is as high as 6 – 8 m/s whereas in the evaluation of Ketzel et al. (1999), this threshold seemed to be lower. In consequence of figure 2 it might be concluded, that concentrations for certain hours can not be calculated if the model does not contain a sophisticated modul to take care of the effects of the traffic produced turbulence.

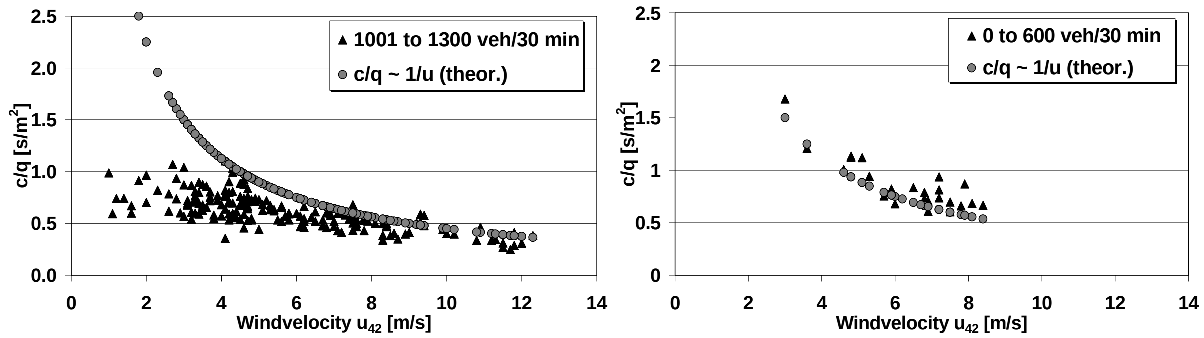

Figure 2.Thirty minute mean additional street canyon NO_x concentration c divided by source strength q as function of above roof wind speed (u_{42}) for wind directions 250 to 270 degrees (perpendicular to street canyon axis). Left for hours with high traffic volume, right for low volume.

CONCLUSIONS

One conclusion, drawn from the above mentioned studies, may be, that procedures and models, although well validated for the determination of annual means and 98-percentiles of vehicle induced NO_2 concentrations, might not be qualified to calculate the concentrations during single hours and might not be qualified to calculate the very high percentiles, needed for the execution of EC Directives 1999/30/EC (18th highest concentration value within a year).

To predict the hourly street canyon concentrations, at least the following requirements can be formulated:

- Traffic volume and driving pattern needs to be provided by real time counts,
- background concentration needs to be provided by local above roof measurements,
- dispersion modelling needs to include sophisticated inclusion of traffic produced turbulence,
- NO-NO_2 conversion model for single hours needs to be applied.

Traffic produced turbulence modelling is presently subject of research, the authors await a consensus about the procedure. There exist NO-NO_2 conversion models, but lack of available input data prevented their application in the above mentioned cases.

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