# J1.9 SIGNIFICANCE OF TRAFFIC PRODUCED TURBULENCE FOR URBAN DISPERSION MODELING

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## 1. INTRODUCTION

Despite the progress in reducing tail-pipe emissions, urban air pollution caused by mobile sources is still a major problem. Consequently, dispersion modeling of traffic emissions in urban areas has been one of the main research areas over the last few years. A variety of dispersion models have been developed that are able to resolve wind-driven, microscale flow and dispersion phenomena. Such phenomena, are typically observed for roof-level wind velocities above a threshold value of 2-3 m/s and strongly affect the transport of pollutants released inside the urban canopy. The street ventilation is then controlled by the interaction between the microscale flow structures and the urban boundary layer flow above roof level and it is argued that both buoyancy-related and traffic-induced air motions are secondary street-ventilation mechanisms compared to the main wind-induced mechanism.

Accordingly, it is commonly assumed that street level concentrations $c$ are inversely proportional to a wind speed $u_{roof}$ measured above roof level. Employing the specific emission per length $E$, and a characteristic length $L$ as scaling parameters, dimensionless concentrations $c^*_{st}$ are calculated by

$$c^*_{st} = c \cdot u_{roof} \cdot L/E \,. \qquad (1)$$

This scaling concept produces significant reduction in modeling efforts in operational air quality studies. However, the concentration data for the two street canyons Göttinger Straße and Jagtvej plotted in Figs. 1a and c, illustrate that the above scaling has certain deficiencies. The data were grouped in classes according to the traffic load (largest for G1 and J1). It is clearly seen that the normalized concentration data ($W_c$ =street canyon width), considerably deviate from the curves (dashed lines) describing the standard velocity scaling $C \cdot W_c/E \propto 1/u$, especially for wind speeds lower than 5 m/s. It is also obvious that the deflection is correlated with the traffic volume. It is more pronounced for classes with a higher traffic volume. Thus, scaling methods accounting for traffic produced turbulence (TPT) could result in a significant improvement.

The present paper summarizes the findings obtained in the TRAPOS research network, regarding the importance of TPT for operational dispersion modeling.

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## 2. TPT PARAMETERISATIONS

Assuming that traffic-induced velocity fluctuations contribute to the dilution of street-canyon pollutants in addition to wind-induced dispersive motions, a dispersive velocity scale can be formulated as

$$u_s = (\sigma_u^2 + \sigma_{ct}^2)^{1/2} = (a \cdot u^2 + b \cdot v^2)^{1/2} \,, \qquad (2)$$

where $a$ and $b$ are dimensionless empirical constants ($v$: average vehicle velocity). Using this velocity scale, the concentration can be normalized as:

$$c^*_{\mathrm{mod}} = c \cdot u_s \cdot L/E = c \cdot L \cdot \sqrt{a \cdot u^2 + b \cdot v^2}\,/E \,. \qquad (3)$$

The value of the constant $a$ depends on street geometry, wind direction and sampling location and is related to the value of the dimensionless concentration for large wind velocities ($c^*_{st} = 1/\sqrt{a}$). The constant $b$ can be derived based on the parameterizations presented in Di Sabatino et al. (2002) that distinguish between situations with light traffic (no interaction of vehicle wakes), intermediate traffic (interacting vehicle wakes) and congested traffic (strongly interacting vehicle wakes). Kastner-Klein et al. (2002) applied these parameterizations and determined $b$ based on air quality and turbulence data for Göttinger Straße. The correlation between street-canyon concentration data and the modified velocity scale $u_s$ (Figs. 1b, d) is much higher than with $u_{roof}$ (Figs. 1a, c).

## 3. CONCLUSIONS

The traditional concentration scaling with a roof-level wind velocity was shown to be inappropriate in urban street canyon situations. It results in significantly overestimated concentrations (see Fig 2a, c) particularly for the largest concentrations. On the other hand, the proposed modified scaling approach accounting for TPT effects results in a substantial improvement in the concentrations predictions (see Fig 2b, d).

## 4. REFERNCES

Di Sabatino S., P. Kastner-Klein, R. Berkowicz, R. Britter, and E. Fedorovich, 2002: The modeling of turbulence from traffic in urban dispersion models – Part I: Theoretical considerations. Prepared for submission to *Env. Fluid Mechanics.*

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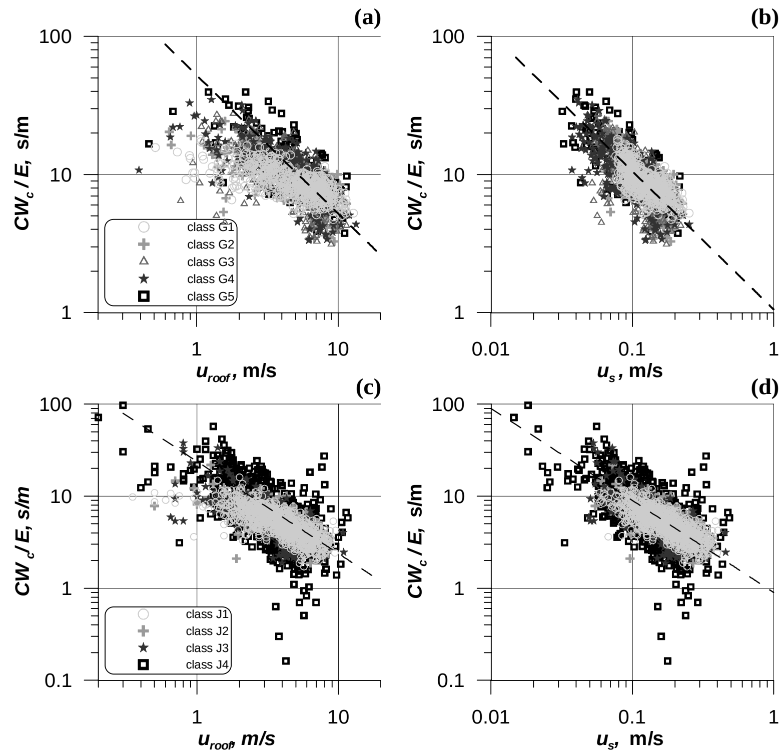


Figure 1: Scaling of Göttinger Straße (plots a, b) and Jagtvej (plots c,d) concentration data with the above-roof-level reference wind velocity $u_{roof}$ (plots a, c) and with a modified velocity scale $u_s$ (plots b,d) accounting for TPT effects.

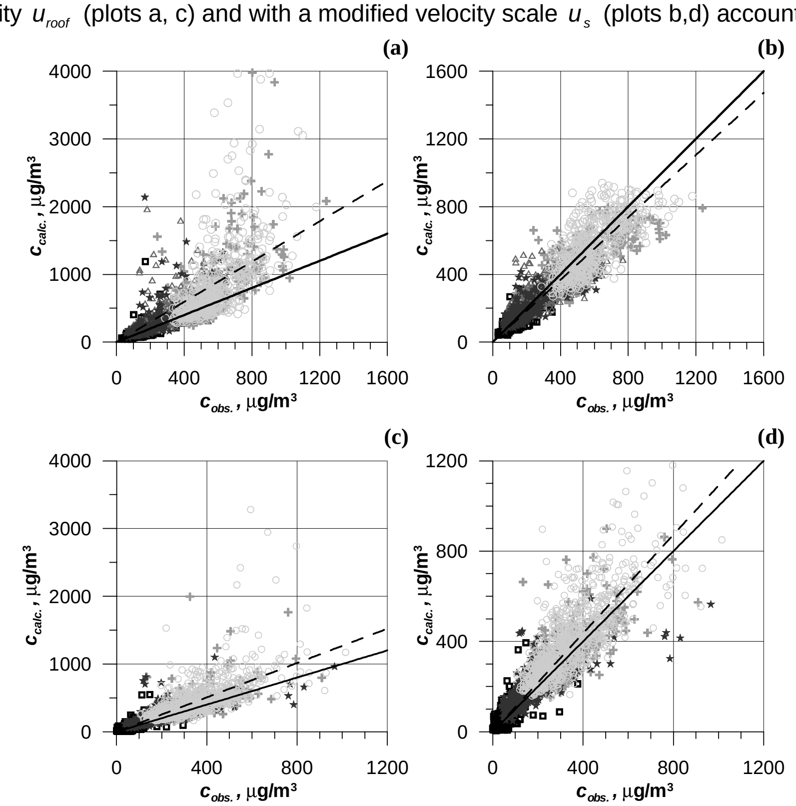


Figure 2: Calculated and measured concentration data for Göttinger Straße (plots a, b) and Jagtvej (plots c,d) using the standard wind velocity scaling (plots a,c) and modified scaling (plots b, d). The solid lines indicate the one-to-one relationship; the dashed lines correspond to the regression line.