MODELLING INCREMENTAL CONCENTRATIONS FROM DOMESTIC HEATING WITH THE REGULATORY LAGRANGIAN PARTICLE MODEL AUSTAL2000

Alfred Trukenmüller[1], Wolfgang Bächlin[2] and Christine Sörgel[2]
[1]Umweltbundesamt (UBA), Dessau, Germany
[2]Ingenieurbüro Lohmeyer GmbH & Co. KG, Karlsruhe, Germany

INTRODUCTION

Fine particulate matter (PM10, PM2.5) is considered the most relevant air pollutant with respect to human health in the EU, reducing the average life expectancy by an average of 9 months. An important source of PM10 emissions is the combustion of wood for domestic heating. In Germany, residential wood burning stoves and boilers contribute some 10 % of national PM10 emissions, slightly more than road vehicle exhaust fumes. Despite their significant cumulative impact on air quality, residential emissions are not a main field of specialized dispersion modelling. Regulatory dispersion modelling is not required for domestic combustion sources. Also, when compared to dispersion modelling of transport emissions, dedicated micro-scale dispersion modelling of residential emissions is scarce. However, Gaussian models and urban scale models which parameterize the urban canopy with a roughness length approach are close to the sources not generally appropriate for resolving near-surface concentration patterns between buildings.

Due to its Lagrangian approach, the German regulatory model AUSTAL2000 (*Janicke, U. and L. Janicke, 2007*) allows for obstacle-resolved modelling of residential areas. By employing the model on two exemplary residential areas under a large number of different boundary conditions, parameterizations are derived which allow to establish a functional relationship between emission factors of wood burning stoves and boilers, and their contribution to the ambient PM10 concentration in the residential area.

METHOD

Where, in a typical regulatory application the emissions of an industrial plant are considered, input to our model are emissions from 320 sources of a 600 m × 800 m cut-out of a low-density, rural residential area. Resulting ambient concentrations are predicted for the same area. A second model domain of the same size represents a high-density, urban residential area including 651 sources (Figure 1).

Emission data

For each building, emissions time series (8760 hourly values) are provided by *Struschka, M., W. Juschka and G. Baumbach* (2007) for a wide range of scenarios including:

- different fuels (gas, oil, log, wood chips, wood pellets, grain),
- different burning devices (stoves and boilers),
- different technical standards of stoves and boilers (best case, state of the art, worst case),
- 15 German climate regions,
- average year and very cold winter.

The emission model of *Struschka, M., W. Juschka and G. Baumbach* (2007) takes into account both stationary and non-stationary states of the combustion process (Figure 2).

Fig. 1; Rural (left) and urban (right) model domain. Shapes represent buildings.

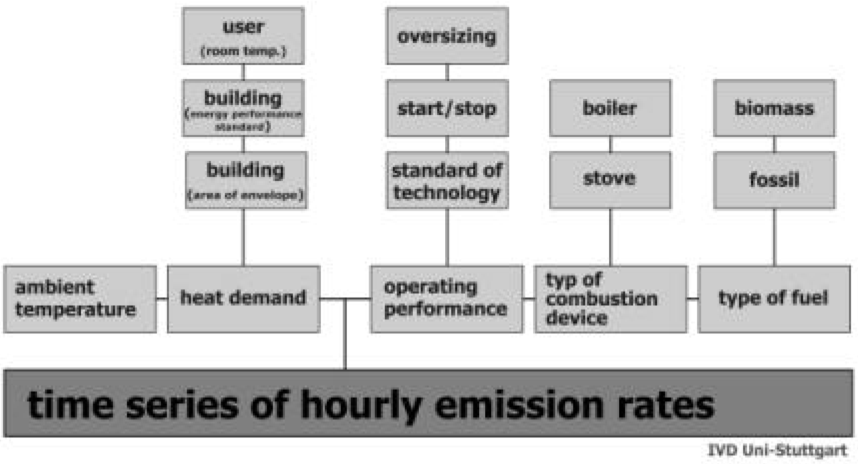

Fig. 2; Emission model (Struschka, M., W. Juschka and G. Baumbach, 2007)

Dispersion modelling

For obstacle-resolved dispersion modelling, AUSTAL2000 can be driven by its own diagnostic wind field model or by an externally created wind field library. In this study, the prognostic micro-scale model MISCAM (*Eichhorn, J., 2004*) is employed to create the wind field libraries for both the rural and the urban domain.

Model runs are performed with hourly time series of wind and atmospheric stability from three German sites, representing low, medium and high wind speed conditions. In addition, the sensitivity of concentrations on flue gas release height is examined by releasing the gases at ridge, 1 m, and 3 m above ridge, respectively.

FIRST RESULTS

While the project is ongoing, relationships have been established between the dust concentration in waste gas at rated heat load of wood burning boilers and the resulting contribution to ambient PM10 concentrations in the residential model area (Figure 3). The results strongly depend on boundary conditions. Lower wind speeds, colder climate (within the range in Germany) and high-density settling may increase PM10 concentrations by a factor of 2 to 3.

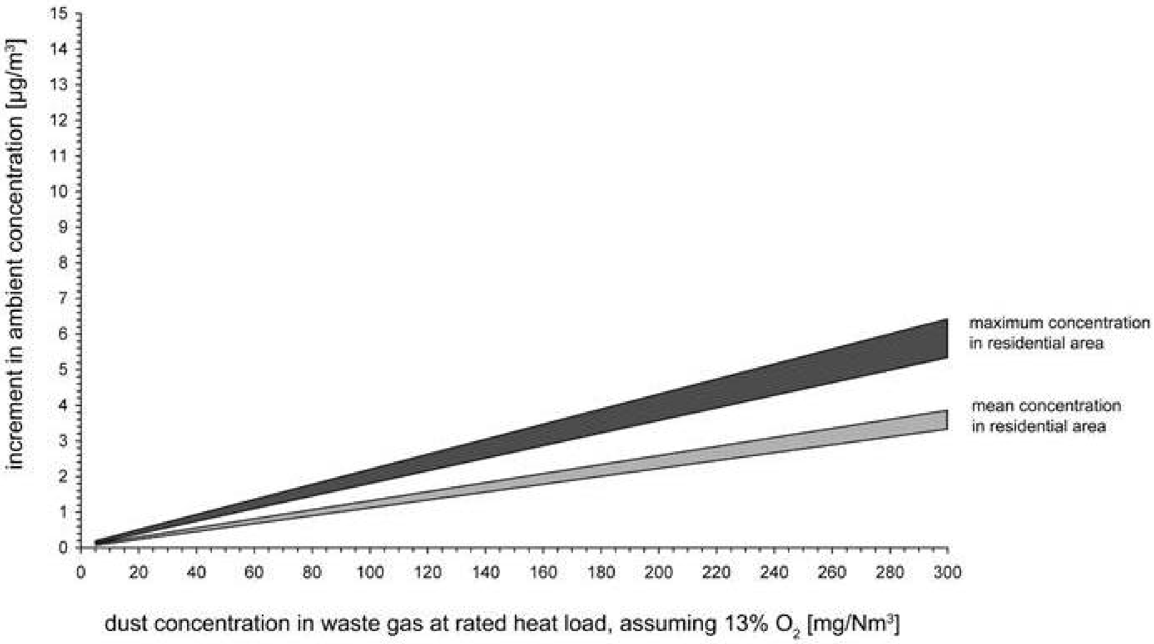

Fig. 3; Contribution of 10 % wood burning boilers to the ambient annual average PM10 concentration in the low-density, rural residential area. Ambient temperatures and winds represent average conditions in Southern Germany.

REFERENCES

Eichhorn, J., 2004: Application of a new evaluation guideline for microscale flow models. Presentation at the 9th International Conference on Harmonisation within Atmospheric Dispersion Modeling for Regulatory Purposes, 1-4 June 2004, Garmisch-Partenkirchen.

Janicke, U. and L. Janicke, 2007: Lagrangian particle modelling for regulatory purposes – a survey of recent developments in Germany. Presentation at the 11th International Conference on Harmonisation within Atmospheric Dispersion Modeling for Regulatory Purposes, 2-5. July 2007, Cambridge.

Struschka, M., W. Juschka and G. Baumbach, 2007: Results of emission modelling and description of the model. Personal communication.