Mass Budget Simulations in the Area of the City of Augsburg

A contribution to subproject GLOREAM

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Aim of the project

The city of Augsburg has been selected for the experimental determination of the emissions of the city. In order to support the experimental design, simulations of the concentrations of NOx, CO, VOC, and their mass budgets are performed with the model system KAMM/DRAIS (Adrian and Fiedler, 1991; Schwartz, 1996). The following questions should be answered by the simulations.

* At what time of the day should the aircraft and tracer measurements be made?
* What differences between the species concentrations upwind and downwind of the city can be expected?
* How big are the contributions of the mass budget components (deposition, chemical transformation) not measured?

The simulations

Radiosonde data from the Munich station for the months March and October over five years with the appropriate meteorological conditions have been selected, which correspond to the desired conditions during the experiment. Only one case is considered here. It is characterised by a wind direction between north and east and a wind speed in the boundary layer lower than 5m/s.

The model area of 50 km × 50 km encloses the city of Augsburg. The topographic data are shown in Figs. 1 and 2.
The emission data have been provided by IER Stuttgart for a typical Tuesday in March. As well as the city, the highways and the industrial areas are the main sources for NO$_x$ (Fig.3). The resolution of the emission data is 1 km. Therefore, the simulations have been carried out with this resolution. The simulated episode started at midnight and ended at 18:00 UTC.
Results

Fig. 4 shows the NO\textsubscript{x} concentration distributions close to the ground for 9:00 and 14:00 UTC. In the morning, the plume of the city is well pronounced whereas it can hardly be recognised in the afternoon.

Fig. 4: Wind and NO\textsubscript{x} concentration distribution (ppb) at 9:00 UTC (top) and at 14:00 UTC (bottom).
The vertical distributions of NO\textsubscript{x} (Fig. 5) along the cross sections A and B (Fig. 4, bottom) demonstrate that the mixing height increases from 200 m in the morning to about 450 m in the afternoon. The concentration differences between the cross sections vary between 30 ppb in the morning and (5–10) ppb in the afternoon.

Fig. 5: NO\textsubscript{x} concentration distribution (ppb) in the cross sections. Top: sections A and B at 9:00 UTC; bottom: same at 14:00 UTC.
The mass budget components given as variation of the mean concentration in the volume per hour are calculated in the area marked in Fig. 4, top. The volume extends up to 750 m above ground including the whole boundary layer. The mass of NO$_x$ in the volume is nearly stationary between 10:00 UTC and 16:00 UTC (Fig. 6). Deposition and chemical transformation processes may contribute to the mass budget up to 15 %, which is not negligible. In the case of CO the vertical transport is also of importance.

Fig. 6: Diurnal cycle of the mass budget components. Top: NO$_x$; bottom: CO.
Conclusions

It was not foreseen to measure the mass in the volume around Augsburg during the experiment. This mass should be nearly constant during the measuring period. However, this is only the case between the late morning and the early afternoon, with the disadvantage that during this time period the concentration differences between the upwind and the downwind side of the city is less pronounced than in the early morning. The horizontal fluxes through all boundaries have to be measured and not only those upwind and downwind of the city, because a homogeneous flow field cannot always be expected during low wind speed conditions in the afternoon. Additionally, the vertical flux at the top of the boundary layer has to be determined experimentally in the case of CO.

References
