

ASSESSMENT OF AIR POLLUTION IN THE CONURBATION OF MUNICH – PRESENT AND FUTURE

Peter Suppan

Institute for Meteorology and Climate Research (IMK-IFU), Garmisch-Partenkirchen,
Germany

INTRODUCTION

Motorized road traffic increasingly faces the dilemma of having to satisfy the increasing need for mobility in terms of both quantity and quality. At the same time, however, it is necessary to consider political demands for a reduction of already noticeable undesired consequences of traffic, while sustainable mobility conditions have to be ensured in the sense of the Agenda 21 adopted by the UN Conference on the Environment and Development (UNCED) in Rio de Janeiro (1992).

Within the project MOBINET (Mobility in the conurbation Munich) new forms of mobility services, innovative traffic technologies and multimodal traffic management (sustainable mobility) have been tested and introduced in the greater area of Munich during a period of 5 years. Apart from the general objective to manage the increasing mobility within the conurbation of Munich also the impact to the air quality due to the traffic was of interest. The impacts of the measures planned were estimated in terms of (i) “benefit for persons directly affected” by the reduction of traffic-induced air pollutants and (ii) “benefit for the environment” by the reduction of the regional tropospheric ozone concentration.

METHODS

With 2000 taken as the base case year of analysis and 2010 as the projected emission scenario year, model calculations with the Multiscale Climate Chemistry Model (MCCM) were carried out for a period of 4 days (18.-22. June 2000). The results obtained from the traffic and regional model and the MOBINET measures to be taken until 2010 were then included in the 2010 emission inventory and simulated as well.

Source-receptor analyses were made to allocate the air chemistry parameters to the individual emission sources. To estimate the impact of a source group on a certain pollutant, seven different simulations had to be accomplished. To minimize the associated uncertainties (non-linearity of chemical processes), the source group to be analyzed was suppressed. The differences between these simulations and the model run with all emissions were summed up. The remaining amount that could not be allocated to any source was considered to be the “non-linear” fraction. This fraction does not only cover “non-linear” processes, but also fractions due to advection and background concentrations (DG-ENV, 2001). These source-receptor analyses were carried out for both the reference year of 2000 and the projection year 2010 with and without the MOBINET measures.

RESULTS AND DISCUSSION

Model Configuration

The fully coupled dispersion model, the Multiscale Climate Chemistry Model (MCCM, Grell et al., 2000), which was used for the simulations, is based on the well-documented fifth-generation NCAR/Penn State Mesoscale Model, MM5. MCCM includes a multiple-nesting capability, non-hydrostatic dynamics and FDDA capability for the meteorology as well as other options for modelling the cloud microphysical processes. Additional to this, two separate gas-phase chemistry mechanisms (RADM2 and RACM) with 39 and 47 chemical species respectively and particulate matter (PM₁₀) as a passive tracer are included. The online

coupling of meteorology and chemistry provides fully consistent results with no interpolation of data in contrast to off-line coupled chemistry and transport models. Validation and comparison procedures with other models can be obtained elsewhere (Suppan and Skouloudis, 2003; Suppan and Schädler, 2004).

The modelling calculations were performed for a 4 days period (18. - 22. June 2000), in which a high turnover of photochemical reactions was observed. Within this period, a steady increase of the daily ozone maximum was measured until the 21st of June. This day also represents the highest concentrations of ozone in 2000. Afterwards a front passed the domain of interest and the ozone concentrations decreased to typical medium levels.

The simulations were carried out with a nesting strategy of 4 nested domains (Figure 1), starting with a European wide domain (54kmx54km and 40x40 grid cells) down to the domain of interest with a grid resolution of 2kmx2km (51x51 grid cells). In the vertical 25 non-equidistant levels were used with the lowest level at 15m above ground. The period of interest was characterised by prevailing south easterly wind directions at the beginning of the calculations. During the period with high ozone values the prevailing wind direction was from west. The whole period was characterized by moderate wind velocity (3-5 m/s). Validation examples show also very good agreement between the model results and the measurements for ozone, nitrogen dioxide and carbon monoxide (Suppan, 2004; Suppan and Schädler, 2004).

Emission Inventory

For the State of Bavaria (in which the domain of interest is included) a detailed emission inventory for the base case and the projection in a spatial resolution of 2kmx2km was available. The high spatial and temporal (1 h) distribution of the pollutants SO₂, NO_x, CO, NMVOC and PM were available in 7 different emission categories (point sources, other industrial sources, others including domestic heating, domestic solvents, agricultural, biogenic and traffic emissions), according to the CORINAIR snap levels.

For the base case 73 % of the NO_x and 26 % of the NMVOCs emissions are related to the traffic within the conurbation of Munich (Figure 2). For the projection into 2010 the fraction of the traffic decreases to 62% for NO_x and to 12% for NMVOC.

In general the emissions projection show decreasing values, only the emission rates close to the airport will increase by 10 to 20 % compared to the base case.

Based on the 2010 emissions, the change of the emissions due to the introduction of the MOBINET measures have been investigated. For the calculation of these emissions a traffic and regional model was applied (MOBINET, 2004). Based on

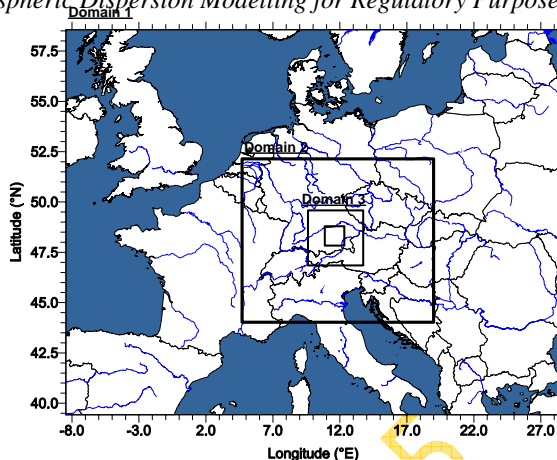


Figure 1: Modelling domains and nesting strategy

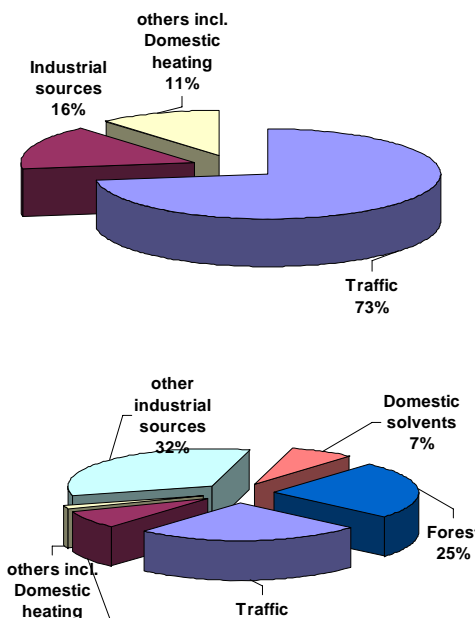


Figure 2: Distribution of NO_x (above) and NOVOC (below) for the base case for the conurbation of Munich

the modified traffic flow due to the introduction of the MOBINET measures a new traffic emissions inventory was calculated. The updated emission inventory for 2010 (which includes the MOBINET measures) shows differences in the range of 2 to 5 % as compared to the emission projection of 2010. Only on single grid cells a change of up to 20 % can be observed.

Air Quality Calculations

According to the calculation of the emission inventory also the air quality calculations were split into 3 sections. At first a base case scenario with the emission inventory for 1996 and the meteorology of 2000 was simulated. In a second step the projected emissions for 2010 and the meteorology for 2000 were used for the calculations called as scenario without MOBINET measures. At last the emission inventory of 2010 including the MOBINET measures were taken as input for the simulations. All calculations were performed for each emission category in order to calculate the source attribution of each of the category to the air quality of 2000, 2010 with and without MOBINET measures.

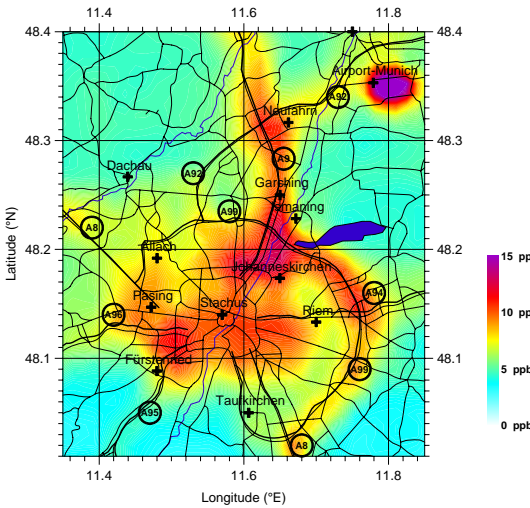


Figure 3: Base case NO₂ concentrations within the conurbation of Munich

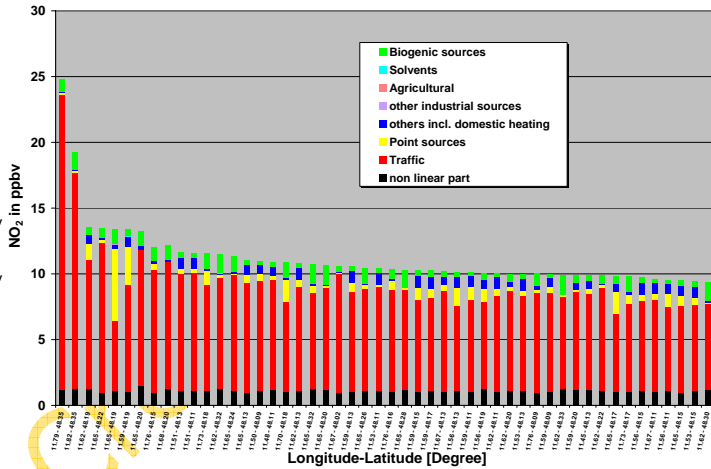


Figure 4: Base case NO₂ source-receptor relationship for the 50 grid cells with highest concentrations within the conurbation of Munich

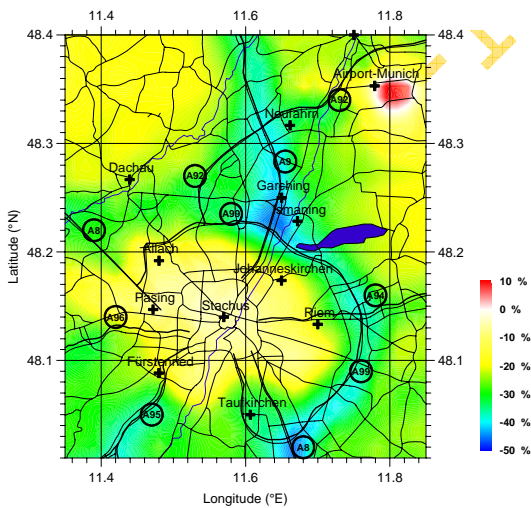


Figure 5: Relative change of NO₂ concentrations between base case and projection

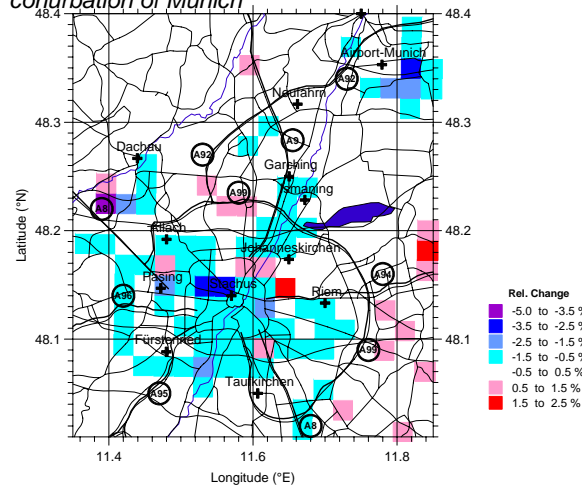


Figure 6: Relative change of NO₂ concentrations due to the introduction of the MOBINET measures

As an example of the NO₂ concentrations in Figure 3 the mean NO₂ concentrations of the modelling period for the base case is shown. The NO₂ concentrations reflect very well the locations with the highest NO_x emissions, the highways, main streets, the city and the airport of Munich. Similar results were obtained for PM₁₀, CO and toluene as well (not shown here).

More detailed information will be given by looking at the source attribution of each pollutant. In Figure 4 the source-receptor distribution for NO₂ is shown for the base case. The concentration at each grid cell includes several source categories. In

accordance with the NO_x emission distribution the NO₂ concentrations caused by the traffic show also the highest values. Due to the non linearity of the chemical processes in the air quality calculations a non linear part which can not be dedicated to a specific source has to be introduced.

The difference between the base case and the projected emissions in 2010 is shown in Figure 5 for the NO₂ concentrations. Here the relative changes show pronounced reductions up to 50% on the highways around the city of Munich. The city itself shows less significant reductions (around 10%). At the airport the NO₂ concentrations will increase by about 10% due to the higher traffic load in 2010. Also for the particles equal reductions were calculated (not shown here). Related to the conurbation of Munich the mean NO₂ reduction is about 24 %, for toluene 30 %, for CO 5% and for PM₁₀ about 30%.

After the introduction of the updated emission inventory due to the MOBINET measures only very small changes can be seen for each pollutant. As an example the relative change of the NO₂ concentration with and without the MOBINET measures are shown in Figure 6. Beside a decrease of the NO₂ concentration of about 4% also an increase of the concentrations in specific regions can be seen. For the toluene concentrations the variability of the change is smaller, for PM₁₀ the variability is higher in comparison to the NO₂ distribution. But in general all pollutants show very small changes. For the relative change of NO₂ a mean value of -0.2%, for CO a change of -0.1 % and for PM₁₀ a change of -0.4 % was simulated.

CONCLUSIONS

Model simulations of the spatial and temporal distribution of selected pollutants reveal significant changes concerning the emission prognoses of 2010. The drastic reduction prognoses for the year 2010 lead to a significant decrease of the primary substances of CO, NO_x, and VOCs. In the urban areas of the city of Munich, along the arterial roads, and at Munich airport, pollutions will be significantly reduced. In addition, the implementation of the MOBINET measures and their effects on emission are reflected. However, the strict emission reduction requirements for 2010 overlap the emission changes already introduced by the MOBINET measures. Associated emission changes (increases as well as decreases) range between 2 and 5% on the average. In individual cases, changes of up to 20% result. Due to their small absolute value, however, they have no relevant effect on the air pollutant concentrations. As a whole, the planned measures (emission prognosis 2010) entail a high "benefit for directly affected persons". A "benefit for the environment" may only be seen in the decrease of the primary substances of CO, NO_x, and VOCs. In particular, reduction of the high NO₂ concentrations on and in the direct vicinity of the arterial roads is of advantage for the environment. A significant decrease in tropospheric ozone concentration at a regional level will not be expected.

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