Ozone Control Strategy Calculations for the Geneva Area

A contribution to subprojects SATURN and GLOREAM

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Introduction

The city of Geneva, which is located in complex terrain, occasionally suffers from high ozone concentrations. We have performed three-dimensional model calculations with a resolution of 1 km × 1 km to investigate the influence of reductions in the emissions of hydrocarbons and nitrogen oxides on the air quality.

Model and data description

The model used for this study is a modified version of the CIT (Caltech, Carnegie Institute of Technology) airshed model (McRae et al., 1982). It is a three-dimensional Eulerian photochemical transport model, which is driven diagnostically by meteorological, air quality, and emission data. The altitudinal range of 6 vertical levels reaches from the surface up to about 2.5 km. The size of the model domain was 40 km × 32 km with a spatial resolution of 1 km × 1 km. The boundary concentrations were obtained by nesting the small grid into a much larger grid with lower spatial resolution.

The chemistry module applied with the CIT model is based on the LCC mechanism (Lurmann et al., 1987). Altogether, the concentrations of 45 chemical species are followed. 36 species are prognostic and 9 (fast reacting radicals) are considered to be in quasi-stationary state. The numerous hydrocarbons are partly lumped, and partly used as surrogates. 106 chemical reactions in the gas phase are presently simulated. We apply an extended version, to which the atmospheric degradation schemes of isoprene and of MTBE had been added (Harley et al., 1993).

Calculations with this model for the Geneva area in connection with a measurement campaign performed in summer 1996 showed a good agreement.
between model results and calculations (Clappier et al., 1997; Krüger et al., 1998). For the calculations we describe here we applied the meteorological conditions of July 10th, 1991, since these showed lower wind speeds and longer residence times of the pollutants than the 1996 case.

The original emission inventory used for this case was prepared by the Société d'Etude de l'Environnement (SEDE), Vevey, Switzerland (Tissot, 1996; Tissot, 1997). It has the same horizontal grid resolution as the model (1 km × 1 km) and was prepared for July 1996 conditions. The temporal resolution is one hour. It considers the emissions from traffic, industries, households, and the Cointrin airport. Different branches of the industry are treated separately as well as different types of vehicles and their mode of usage. Weekday, Saturday and Sunday emissions are distinguished. The biogenic emissions were provided by the Paul-Scherrer-Institut (PSI), Villigen, Switzerland (Keller et al., 1995) with a spatial resolution of 5 km × 5 km and included isoprene, mono-terpenes and NO.

Scenario calculations

14 model runs were performed for July 10th, 1991 in which the emissions of either NOx or VOC (volatile organic compounds) or both were reduced from their original values. Table 1 gives an overview of these scenarios. As base emissions the values of 1996 were used. The meteorological conditions were kept unchanged for all runs as well as the concentrations at the grid boundary, which were taken from the run of the coarser model for the 1996 case. The daily maximum ozone values of the scenarios were compared at different areas within the model domain. A similar method had been applied by Kübler et al. (1996) for the maximum within a whole model domain. The results for the different areas will be described below.

Table 1: Reductions of VOC and NOx for the calculated scenarios, in percent.

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<th>No.</th>
<th>VOC</th>
<th>NOx</th>
<th>No.</th>
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<th>NOx</th>
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Results

Only emission reductions inside the domain have been investigated in this study. Therefore the upwind zone of the city shows only minor effects. In the city plume the transition from more VOC to more NO\textsubscript{x} control can be observed. This is displayed in Fig. 1.

In the city centre the response to NO\textsubscript{x} or hydrocarbon reduction is nearly equal. Following the plume (see figure caption) a reduction of NO\textsubscript{x} becomes more efficient. On the other hand there are regions in which the maximum ozone concentration is more controlled by hydrocarbons. The area downwind of the airport (at the top of Fig. 1) is an example.

Conclusions

The response of the daily ozone maximum to emission reductions varies strongly with the location. Three-dimensional model calculations with a spatial resolution of 1 km × 1 km have shown that within the near plume of a city areas can occur at the same time which respond more to a reduction in NO\textsubscript{x}, and others which respond more to a reduction in hydrocarbons.

Acknowledgements

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References


Ozone Control Strategy for the Geneva Area

Fig. 1: Isopleths of the daily ozone maximum (50 to 80 ppb) at intervals of 2 ppb in the grid cells of the downwind area of Geneva. About one quarter of the model domain is shown. The urban centre can be found in the upper half on the right, e.g. cell $x = 15$, $y = 13$. The wind was blowing nearly along the diagonal from the upper right to the lower left corner. The axes for each square range from 100 to 0 % VOC control (horizontal) and from 100 to 0 % NO$_x$ control (vertical). The value for no reduction is displayed in the upper right corner of each square. Horizontal isopleths mean that only a reduction in NO$_x$ would lead to a reduction of ozone, while vertical lines show that a reduction in VOC would be more effective. Empty squares, as they appear at the bottom close to the model boundary, indicate that emission reductions would have no effect at all.


