ON THE ANALYSIS OF IMPACT OF CHEMISTRY, TRANSPORT AND EMISSION SOURCES ON TROPOSPHERIC OZONE PRODUCTION IN MODEL SMOG

Tomas Halenka, Josef Brechler
Dept. of Meteorology and Env. Protection, Faculty of Math. and Phys., Charles University, Prague, Czech Republic

INTRODUCTION

A common problem of almost all urban areas in Europe is air-pollution due to photooxidation (summer photochemical smog). The episodes of this smog occur in summer months as consequences of high production of ozone precursors which under specific meteorological conditions with main impact of solar radiation produce this type of air-pollution in urban areas. Tropospheric ozone, the main part of the summer photochemical smog, is a result of a cycle of the photochemical reactions. To accept some appropriate measures that can prevent the high O_3 concentration episodes it is necessary to know appropriate contribution of different sources, with respect to their type, height, distance etc. With respect to nonlinearity of the reactions and complexity of the problem this is not so easy as for sulphur problem. To estimate role of emission intensity of individual sources, chemistry along the trajectory from the sources and mixing of pollutants from individual sources as well it is essential to study the contribution of individual parts of emission plumes – so called "puffs" – to the places of interest. Another possible way to study the contribution of individual sources or their groups is scenario run with appropriate emissions switched on and off and comparative analysis of the results. The main goal of the presented model study is to show, how the different types and individual emission sources in particular can affect the O_3 ground concentration.

METHODOLOGY

The Lagrangian photochemical model SMOG is used in this study (see Bednar, 2001, 2002). The model is based on spreading of puffs along the trajectories, with summer daily photochemistry in individual puffs and mixing between the puffs. The model is driven by meteorological conditions from ETA model, trajectories are evaluated on the level of individual sources from the ETA wind fields involving thermally enhanced heights for appropriate types of sources like from heating. There are emission sources included both as point sources (significant sources in terms of emission intensity in NO_x or VOC, height of the source) or area sources (grouping of less important, smaller emission sources and sources from transportation). The chemistry involved is simplified including 18 compounds, with lumping of the compounds for VOC's due to efficiency of the computation and due to availability exact information on chemical parameters of individual compounds as well as individual compounds emission intensity. Example of sources is provided in Fig. 1. Separate groups are for biogenic VOC's, i.e. isoprenes and terpenes, see Fig. 2.

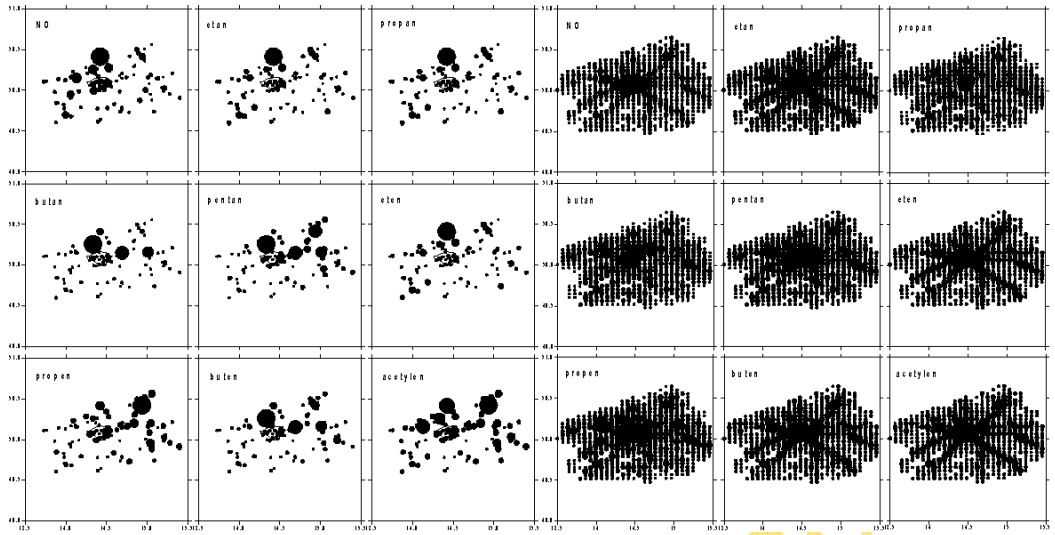

Fig. 1; Point sources (left panel) and area sources (right panel) around Prague City. Size of symbols proportional to the intensity of sources.

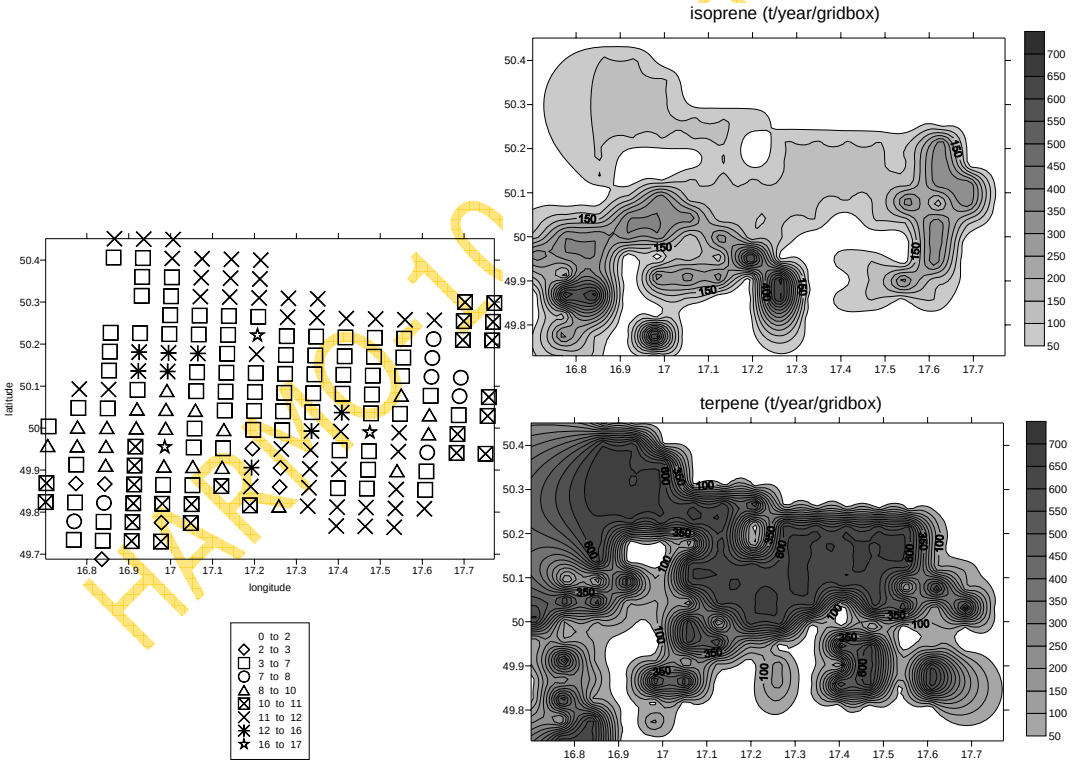

Fig. 2; Biogenic emission sources (left panel: 0-without data, 2-mixed forest, 3-coniferous forest, 7-forest and cultivated areas (fields), 8-forest and meadows, 10-agricultural area with prevailing arable land, 11-mixed agricultural area with arable land and meadows, 12-agricultural area with prevailing meadows, 16-built-up areas (industrial areas or settlement) and their intensities under photochemical smog formation conditions.

RESULTS

Urban experiment

In "urban" experiment with example of overall ozone plume of Prague City for September, 19, 2003, presented in Fig. 3, the contributions of the puffs on the trajectories from the individual sources are evaluated for the area of maximum concentration. The position of individual puffs contributing in this point is shown in Fig. 4 together with the relative part of total concentration. Thus we can trace the origin of the contributions providing the information not only about sources themselves but giving some information about influence of progress of chemistry between and/or in puffs along the trajectories as well. Results show great importance of local sources including traffic as well as point sources, with significant influence of remote strong emission sources.

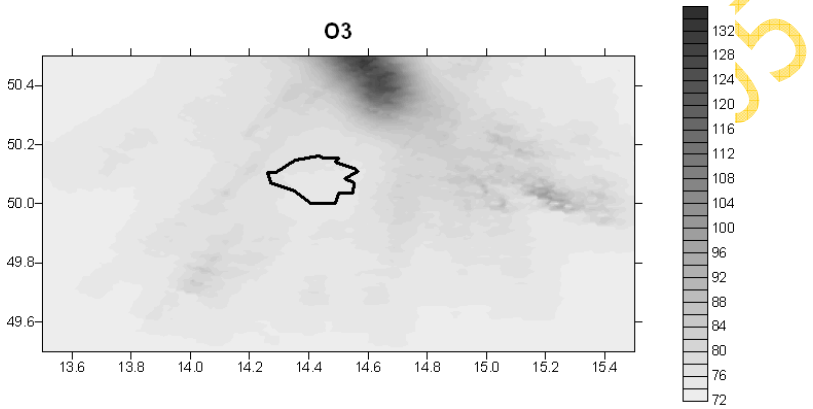

Fig. 3; Prague ozone plume, September, 19, 2003. Concentration of surface ozone in μg/m^3.

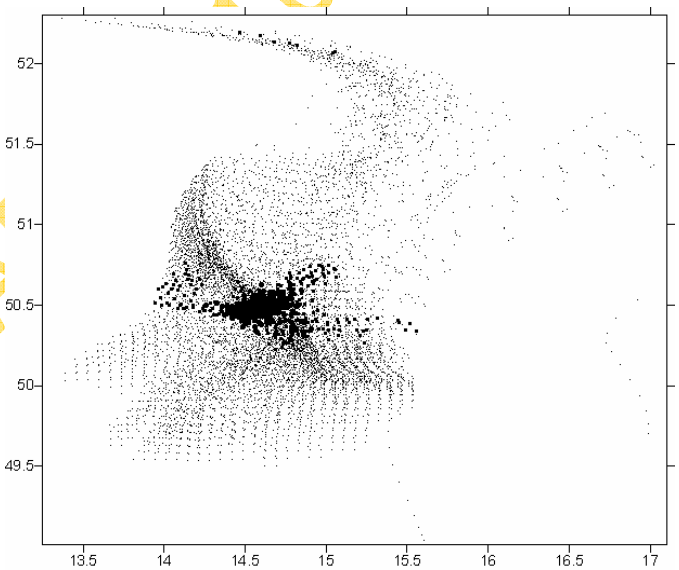

Fig. 4; Position of individual puffs contributing in the area of ozone maximum concentration (50.48N, 14.58E) of Prague ozone plume, September, 19, 2003. Size of symbols proportional to the relative contribution to the total concentration – most of contributions negligible.

More detailed insight into the contribution of individual types of sources is presented in Fig. 5, where important point sources as well as traffic contributions are shown. Analysis of the origin of these puffs pointed out great importance of local sources including traffic, with significant influence of remote strong emission sources.

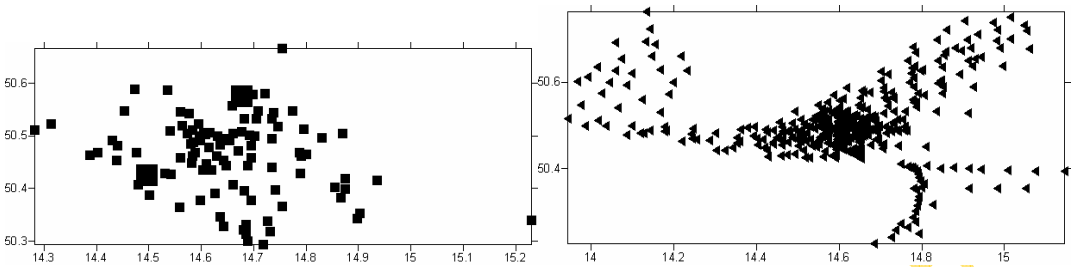

Fig. 5; Position of individual puffs contributing in the area of ozone maximum concentration (50.48N, 14.58E) of Prague ozone plume, September, 19, 2003, from the important point sources (left panel, 7% of total contribution) and from the traffic sources (right panel, 64% of total contribution). Size of symbols proportional to the relative contribution to the total concentration.

Remote experiment

In "remote" experiment we examined the influence of biogenic emissions on ground concentration of ozone. We used another possibility of studying the impact of some compounds, i.e. comparing the simulation switching the inclusion of the compound on and off. Significant increase of ozone concentration with biogenic emission involved can be seen in Fig. 6 under typical conditions for summer photochemical smog formation. For remote mountain location Cervenohorske sedlo with available measurement we provide the comparison for June 2002 in Fig. 7. It can be clearly seen much better performance of the model with the biogenic emissions involved.

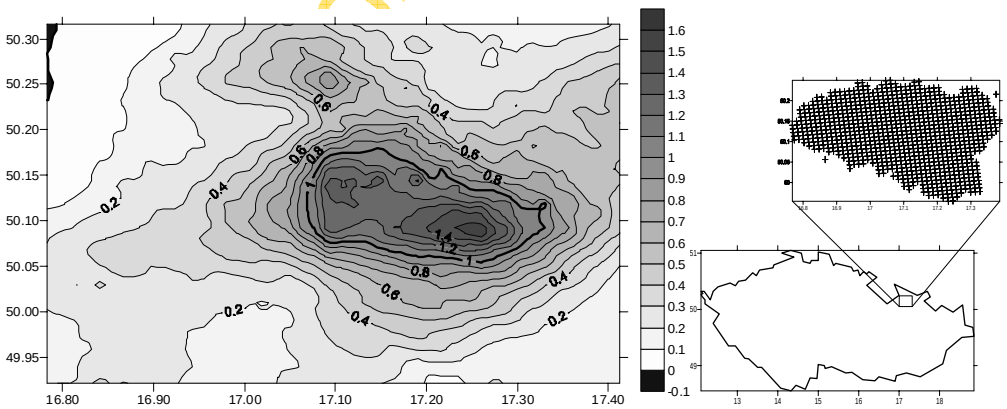

Fig. 6; Comparison of model experiment with biogenic emission switched on and off with measurement for daily ground concentration of ozone. (typical conditions for summer photochemical smog formation - relative change).

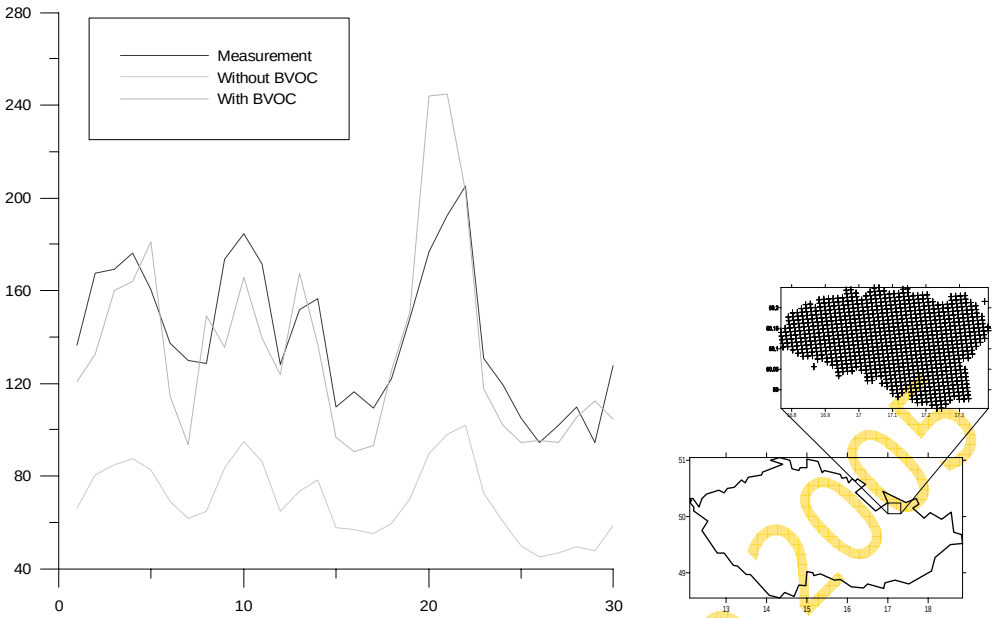

Fig. 7; Comparison of model experiment with biogenic emission switched on and off with measurement for daily ground concentration of ozone ($\mu g/m^3$) for Cervenohorske sedlo in June 2002.

ACKNOWLEDGEMENTS

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