

**A PROJECT “TRANSFORMATION OF AIR-POLLUTION, MODELLING ITS
TRANSPORT AND DISPERSION”**

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INTRODUCTION

In 2001 a new four-year complex project financed by the Czech Ministry of Environment has started. The main achievements of the project can be summarized as follow:

- to increase our knowledge of the summer photochemical smog formation in the area of the Czech Republic together with better quantification of the polycyclic hydrocarbons concentrations,
- to quantify a relative shear of individual types of emission sources on the photochemical smog production in different environmental conditions (e.g. urban or suburban areas, rural areas etc.) including biogenic emissions impact,
- to research and verify the chemical transformation mechanisms of the processes connected with the air-pollution releases into the atmosphere and their transport, dispersion and deposition modelling, their impact on human health state and ecosystem.

In the framework of this project several particular task are solved. They consist in such items as is the updating and improvement of emission inventories in connection with the VOC emissions composition, for example, The next one will deal with biogenic emission and they role in the air-pollution problems and the estimation of their impact on the environment in various circumstances.

Next particular task deals with monitoring, sampling and chemical analyses of air-pollution. The processes of chemical transformations that various kinds of emissions undergo in the air have been studied, too. Data from time limited field campaigns together with information from the existing monitoring network will be used. Campaigns are planned in such a way that both information about air quality from urban areas and relatively clean “background” areas can be collected and analysed.

Last but not least task deals with modelling activity. In the framework of this activity a spatial distribution of tropospheric ozone is modelled on the different resolution. A overview of the ozone distribution in the large area (the area of the whole Czech Republic with resolution equal to tens of km in horizontal or some great part of the mentioned area) will be given together with local modelling with very high resolution. Model results will be tested against measured data that will be collected both from field campaigns and from existing monitoring networks.

EMISSIONS

As information about various kinds of emissions is an important input for a majority of activities involved in the presented project, in the subsequent paragraph we will mention emission situation in the Czech Republic in the period 1990 to 2000. This situation is illustrated by means of Table 1 (*Machálek, 2001*) where the emissions of SPM (suspended particulate matter), sulphur dioxide SO₂, oxides of nitrogen NO_x, carbon monoxide CO and a mixture of the hydrocarbons called volatile organic compounds – VOC are presented in kilotons per year.

Table 1. Emissions in the Czech Republic in 1990 - 2000 (in kt/year).

Year	SPM	SO ₂	NO _x	CO	VOC's
1990	631	1876	742	1055	435
1991	592	1776	725	1102	398
1992	501	1538	698	1045	359
1993	441	1419	574	967	338
1994	355	1278	434	1026	310
1995	201	1091	412	874	286
1996	179	946	432	886	284
1997	128	701	423	877	272
1998	86	443	413	767	269
1999	67	269	390	686	248
2000	57	265	397	649	240

The above presented Table 1 gives an absolute value of emissions. Next important information is an emission per one square km per year. This value can be issued also as an emission per one square km per year per capita in order it could be possible to compare different states, for example. In the Czech Republic the emissions per one square km per year were in 1999 as they are written in Table 2 (Machálek, 2001).

Table 2. Emissions per one square km per year in the Czech Republic in 1999 in kt/year.

Area (km ²)	Population density	SPM	SO ₂	NO _x	CO	VOC's
78866	131	0.8	3.4	4.9	8.7	3.4

The following Table 3 (Machálek, 2001) shows the expected situation in the emissions of SO₂, NO_x and VOC's in 2010 from individual categories of emission sources. Emissions from stationary emission sources can be found in emission inventories REZZO 1, REZZO 2 and REZZO 3 where REZZO 1 contains the most powerful point sources (stacks of power plants, heating plants, industrial sources, for example), REZZO 2 are the medium emission point sources (block heating plants or small factories, for example) and REZZO 3 deals mainly with local heating sources. Mobile sources are documented in the REZZO 4 inventory.

Table 3. Expected emissions from individual categories of emission sources in 2010.

Emission sources category	SO ₂		NO _x		VOC's	
	kt/year	%	kt/year	%	kt/year	%
REZZO 1	171	71	110	38		
REZZO 2	10	4	6	2		
REZZO 3	42	18	10	4		
Sum of stationary sources	224	93	126	44	150	64
Mobile sources	17	7	160	56	70	36
Sum of all sources	241	100	286	100	220	100
Given upper limit for 2010	283		286		220	

In all the above mentioned tables the VOC's emissions are presented as a single value without any additional information about the composition of this group of hydrocarbons. This information is very important especially for modelling as the property of individual compounds in the whole amount of VOC's can differ significantly. As far as this problem concerned it can be said that:

- a spectrum of VOC's from combustion processes is significantly different from that of evaporation,
- this spectrum depends also on the kind of petrol used,
- there is a great difference when oil is used as a fuel.

This fact can be illustrated by comparison of species creating VOC sampled in different places in the Czech Republic (see, for example, *Leníček*, 1997). These places differ mainly in the industry structure and the traffic intensity and kinds of cars (passenger cars, heavy lorries etc). There are significant differences in concentrations of some compounds as toluene, for example.

The above information deals with emissions due to human activity. Biogenic emissions are not involved in the above mentioned information. On the other hand it is well known that the biogenic emissions of CO from forests can be quite high and, for example, isoprene together with other organic compounds is also emitted significantly from the coniferous forests.

FIELD CAMPAIGNS

To improve our knowledge about the role of biogenic emissions on the formation of ground level photooxidative air-pollution (mainly ozone) several field campaigns are planned and they will occur at several places. The results of analyses from these campaigns could help us to better understand all processes in the atmosphere that the emissions of different hydrocarbons have to undergo. When we will be able to describe them then it will be possible to improve the description of chemical reactions the consequences of which are the high concentrations of so-called summer photochemical smog.

As there can be various circumstances that can affect photochemical smog creation several different places for measurement were chosen. They could represent various types of environment one can meet. There will be a monitoring activity in such a site, that can represent an urban environment with industry, traffic and other, for urban environment typical activities and, of course, also typical composition of emissions. Another monitoring activity will take part in relatively clean condition far distant from heavy traffic and cities and towns. Data collected from these field campaigns could help us to understand better and better describe atmospheric chemistry, as it has been written above.

MODELLING

Modelling activity in the framework of the mentioned project mainly deals with distribution of ground concentration of photooxidative air-pollution that can be represented with tropospheric ozone O₃. To model this distribution it is necessary to couple the chemical submodel with some meteorological pre-processor that would generate necessary meteorological information as flow field, temperature distribution, information about vertical temperature stability, for example. Now, the system consisting of the meteorological *ETA* model (*Mesinger et al.*, 1988) and a chemical submodel *SMOG* (*Bednár et al.*, 2001) has been tested for the problems on mesoscale. Chemical submodel *SMOG* has been developed at the Department of Meteorology and Env. Protection, Faculty of Mathematics and Physics, Charles University, Prague, meteorological prognostic model *ETA* is that used by the US NCEP and now it is routinely run at the same department. In the next future another possibilities consisting of mesoscale model *MM5* (*Grell et*

al., 1994) coupled with air-pollution model *CAMx* (*User's guide*, 1998) is planned to be tested together with a system consisting of mesoscale model *METRAS* (*Schlünzen et al.*, 1996) and submodel *SMOG*. Mesoscale model *METRAS* has been developed at the Meteorological Institute of Hamburg University.

A very local high resolution modelling of the spatial distribution of O₃ concentration in the areas close to selected locations where field campaigns takes part is also prepared. To solve this task a new CFD model able to describe local factors affecting distributions of meteorological elements is prepared.

CONCLUDING REMARKS

Despite the improving situation in so-called “classic” emissions (like SPM or SO₂) release, there remain problems having their origin in the past where the emission of these species were high in due to this fact also depositions were high and this led to the degradation of ecosystems. Another problem comes from the fact that there are still high emissions of species originating in car traffic which results in the photooxidative smog creation in summer months. To understand better all these processes the result of which is the photooxidative smog and to describe better the impact this kind of air-pollution on living systems is one task of the presented project.

The second task comes from the fact that up to now only impact of emissions originating in human activity was taken into account. But there are a lot of, let us say, natural emissions coming from forests, for example, that are also quite important. They have to be taken into account into studies of the emission impact as they can act together with “human activity” emissions and intensify this impact. This is also a part of the presented project.

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