PM10 MAP AND POPULATION EXPOSURE FOR SWITZERLAND

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ABSTRACT
With a new model, PM10 concentrations for Switzerland are calculated, and mapped: Particles from primary PM10 emissions, secondary aerosols from precursor concentrations and regional PM10 components due to emissions from European countries. The model is implemented in a geographical information system. Results for 1997 show that a large area of the Swiss Plateau, including urban and sub-urban locations, have concentration values above the ambient air quality standard of 20 µg m^{-3}. Since mainly the built-up area is concerned, 61 % of the inhabitants (4.3 million of persons) live within the area of excessive PM10 pollution levels. For later purposes, the model is intended to be generalized to separate modeling of PM10 and PM2.5 concentrations. The model results are already used as a tool for regional air pollution management.

KEYWORDS
Swiss PM10 emission inventory, PM10 concentration model, population exposure, regional PM10 pollution control

INTRODUCTION

PM10 (particulate matter with an aerodynamic diameter of less then 10 µm) is a matter of increasing concern. In March 1998, Switzerland adopted a PM10 air quality standard of 20 µg m^{-3} as annual average. The Commission of the European Union proposed ambient air quality standards of 30 µg m^{-3} by the year 2005 and of 20 µg m^{-3} by 2010 as well. Measurements, however, show that the standard is exceeded in most urban areas.

Within the framework of the international research program „Health Costs due to Road Traffic-Related Air Pollution“ (the results of which were presented at the third Ministerial Conference on Health, Environment and Transportation in London, June 16th- 18th 1999), a comprehensive model has been developed capable of predicting annual PM10 concentrations for the whole of Switzerland with a spatial resolution of 1 km^2.

EMISSION INVENTORS

For the modeling of the primary PM10 components, a detailed emission inventory is used (see table below). The traffic emission inventory takes into account PM10 emissions from tailpipe exhaust (mainly from diesel engines), tire wear, brake dust, and resuspension of particles from road surfaces. Other inventories cover industrial processes, agriculture, forestry and domestic activities (heating, gardening, hobby).

emittents	specification	PM10 emission
road traffic	tailpipe exhaust	8.2%
	tire wear	7.9%
	brake dust	4.9%
	resuspension, abraison	30.0%
	sub-total road traffic	51.0%
industry		28.5%
agriculture, forestry		16.7%
domestic		3.7%
sum		100% = 32'200 t/a

Table 1. Swiss PM10 emission in 1997. Over 50% is caused by the road traffic, 30% by resuspension and abraison from roads alone.

METHODS OF CONCENTRATION MODELING

Two concentration profiles (ground-level for traffic sources, medium-level for chimneys) are used to model the annually averaged dispersion in the scale up to 150 km. An asymmetric dispersion due to the specific wind-directions of the Swiss Plateau is included.

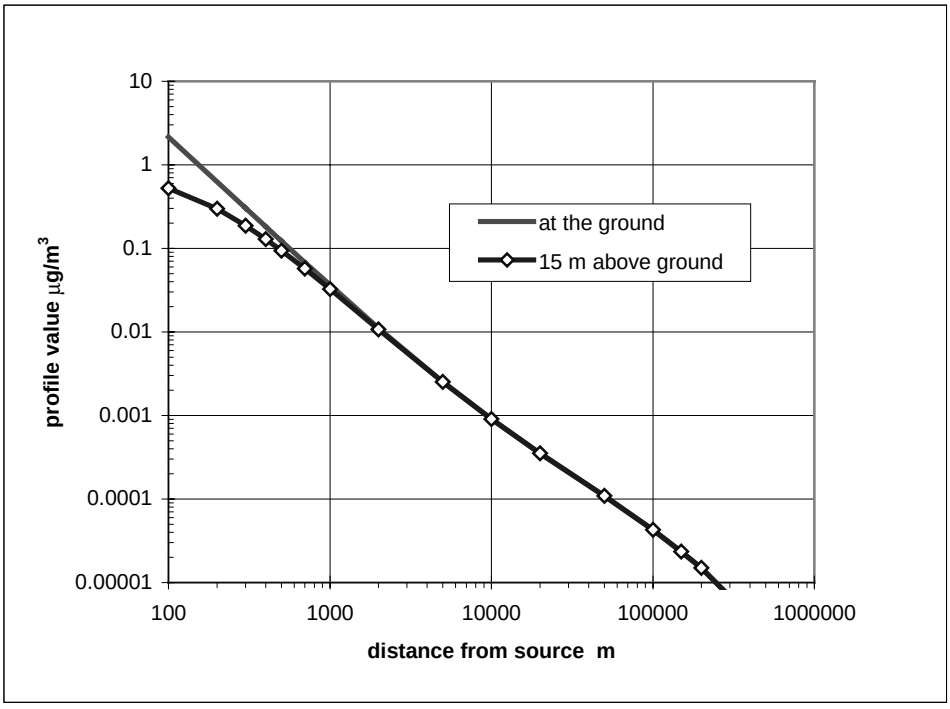

Figure 1. PM10 concentration profiles for the dispersion calculation for two different emission heights at the ground (traffic and agricultural sources) and at 15m above the ground (industrial and domestic sources)

Secondary PM10 components like nitrate, sulphate, ammonium, and organic matter, which are produced in the atmosphere from precursors in the gaseous phase, are calculated by using inventories for the precursor concentrations of NO_2, SO_2 and VOC. NH_3 is supposed to be abundantly present in the atmosphere, such that every sulfate and nitrate ion is completely neutralized by ammonium ions.

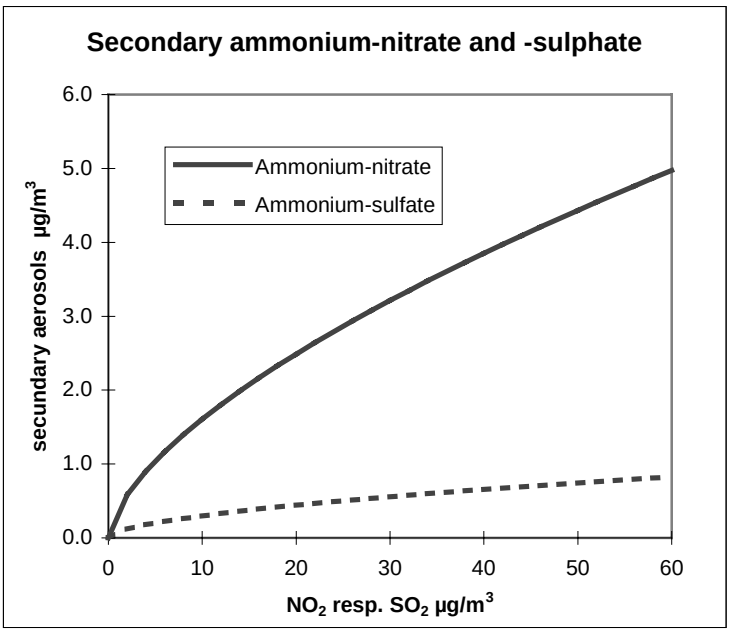

Figure 2. Functional dependence between gaseous precursor concentrations (NO_2, SO_2) and the corresponding secondary aerosol concentrations of ammonium-nitrate and ammonium-sulfate (European Commission, DGXI, 1997)

The regional background contribution to the PM10 concentrations in Switzerland is estimated from a European-scale model (ca. 11 µg m^{-3} on the Swiss Plateau). 1 µg m^{-3} is added for natural PM10 found in Switzerland (mainly wind-blown desert dust). Biological components are neglected for the annual average.

RESULTS

A PM10 map of Switzerland (annual average) for 1997 and the corresponding PM10 population exposure are the main outcomes of the project. The contributions of the different source groups (passenger and freight road traffic, others) and of the different components (elemental carbon, organic matter, nitrate, ammonium, sulfate, others) are estimated separately. Different concentration categories can be characterized. The concentrations are exceedingly high compared to the ambient air quality standard for the annual mean at most urban and suburban locations in Switzerland.

categories	PM10 concentration in µg/m^3			traffic caused
	annual mean	min.	max.	part in %
urban, town-centers	29	25	43	46%
suburban traffic-exposed sites	24	16	36	39%
other suburban sites	22	14	29	36%
rural sites, motorways < 1 km	22	15	35	38%
rural sites	18	15	26	32%
air quality standard (annual mean)	20			---

Table 2. Swiss PM10 concentrations in 1997 for different categories. The traffic caused part ranges from 30% at rural sites to 46% in town-centers. In the table, the spatial average values of each category are given, maximum values range up to 60%.

Validation of the model results has been done by means of PM10 observations from 17 sites in Switzerland; for some of these stations, the main PM10 components are available as well. Results show a good correspondence between predictions and observations of the whole concentration, whereas the model tends to underestimate the elemental and organic carbon part and to overestimate the secondary ammonium-nitrate.

The results for the population exposure show that 61% of the Swiss population (corresponding to 4.34 million inhabitants) live at sites with excessive concentration above the ambient air quality standard of 20 µg m^{-3}.

PM10 concentration µg/m^3		population exposure		
class	mean of class	total	0 - 14 years	> 20 years
< 5	2.5	0.0%	0.0%	0.0%
5-10	7.5	1.2%	1.3%	1.3%
10-15	12.5	5.7%	6.6%	6.5%
15-20	17.5	31.8%	36.4%	36.6%
20-25	22.5	42.5%	41.3%	41.8%
25-30	27.5	14.6%	11.5%	11.1%
30-35	32.5	3.0%	2.1%	1.9%
35-40	37.5	0.9%	0.6%	0.5%
> 40	42.5	0.3%	0.2%	0.2%
inhabitants 1997		7.08 mi.	1.95 mi.	5.45 mi.

Table 3. PM10 population exposure in Switzerland 1997: Total population, children 0-14 years and persons over 20 years (inhabitants in million).

OUTLOOK

The model described is not only used in the project „Health Costs due to Road Traffic-Related Air Pollution“, but is also used to support cantonal authorities on their local PM10 pollution management in order to reduce the exceeding PM10 concentration levels.

As a next step, the model will be generalized: In addition to the PM10 emission inventory, the fractions of PM2.5 and PM0.1 will be implemented. As well, three separate dispersion profiles for the fractions PM0.1, PM0.1-2.5 and PM2.5-10 will be determined. This allows to model each category separately. At the moment, the additional emission data and meaurements in Switzerland for PM2.5 are mostly available, whereas for the split of PM0.1/PM0.1-2.5 the emission data is not known for each category, and systematic measurements of PM0.1 have not been established yet in Switzerland.

REFERENCES

European Commission, DG XI (1997), *Economic evaluation of air quality targets for SO_2 , NO_2 , PM10 and Pb,* Final report, Institute for Environmetal Studies, vrije Universiteit Amsterdam, October 1997.