

POEMPM: an emission model for size and chemical description of particulate matter

Contribution to subproject SATURN

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Summary

Estimate of particulate emissions is becoming more and more relevant for the evaluation of air quality, because of its influence on human health and ecosystem.

Therefore the design of transport and chemical model systems is necessary to provide pollution control strategy and cost-effectiveness analysis. For this purpose, emission models providing particulate matter emission fields have to be implemented.

In this work POEMPM, a model for the evaluation of PM emissions providing size and chemical description, is presented.

Introduction

Particulate Matter has both antropogenic and biogenic origin. It takes an important part in hydrological cycle of the Earth having repercussions on chemical composition of atmosphere components and affecting on air quality.

In other terms PM influences human health and ecosystem and therefore it is very important an exhaustive study of possible pollution control strategies.

Presence in urban area of high particle concentration with a wide source range causes increased of interest to health effects of this atmosphere component. Although reduction of carbon use, road transport (diesel engine), domestic heating and industrial processes still produce important emissions in atmosphere. Impact of particulate matter in physic and chemical processes has to be described in terms of suspended mass, size distribution and chemical composition.

Chemical and transport models can be employed for the evaluation of possible pollution control strategies; they need suitable tools to evaluate the actual emission fields for the gas and aerosol phase, and to provide possible alternative emissions scenario.

Objectives

First aim of this work is the design of an emission model providing PM emission fields (Carnevale et al., 2001); for this purpose an exhaustive study of size distribution and chemical composition of particles emitted from different sources has been conducted (Martin et al., 2000, Hall, 1998, Hall 2001, Andersson et al., 2001), in order to define chemical and size profiles.

POEMPM can provide both emission inventories and alternative scenario estimations with spatial and temporal appropriate resolution for transport and chemical model systems.

The model has been applied to Lombardia Region, a densely inhabited and industrialised area, located in Northern Italy.

Activities

Methodology of POEMPM is based on a top-down approach applied to yearly domain emissions, grouped into CORINAIR categories (Catenacci et al., 1999, Carnevale et al., 2001). Starting from these information, the procedure resolves the aggregated data in spatial and time scale, splitting total PM emissions into size and chemical classes.

The procedure is developed on four steps:

- Spatial split of total domain emissions into municipal areas;
- Hourly modulation of yearly municipal emissions;
- Speciation of total PM emissions into size and chemical classes;
- Splitting of hourly municipal emissions on a grid domain.

As CORINAIR category emissions can be due to one or more technologies, fuels, and activities, each pollution process is characterised by own spatial distribution, temporal modulation and speciation profile.

Spatial resolution is yielded using *surrogate variables*, highly correlated with emissions and defined by means of national and local statistical sources, GIS and land use information. The main indicators for the temporal modulation of emission activities are fuel use, temperature, degree-days, working time, production cycle, traffic counts, road statistics.

Using suitable speciation profile total PM emissions are split into 10 dimensional classes, from 0 to 11.39 μm , and 6 chemical categories (Organic Carbon, Elementary Carbon, Sulphates, Nitrates, Water, Other).

Because epidemiological studies have shown that fine particles (diameter $< 1 \mu\text{m}$) have a deep impact on human health, the size classification is focused on small diameter classes.

POEMPM is therefore an important tool for a model system for air quality study, providing input needed by chemical and transport model carrying out simulation on a considered domain (Figure 1). Using reduction factors, the emission model can provide alternative scenarios, consistent to PM abatement technologies.

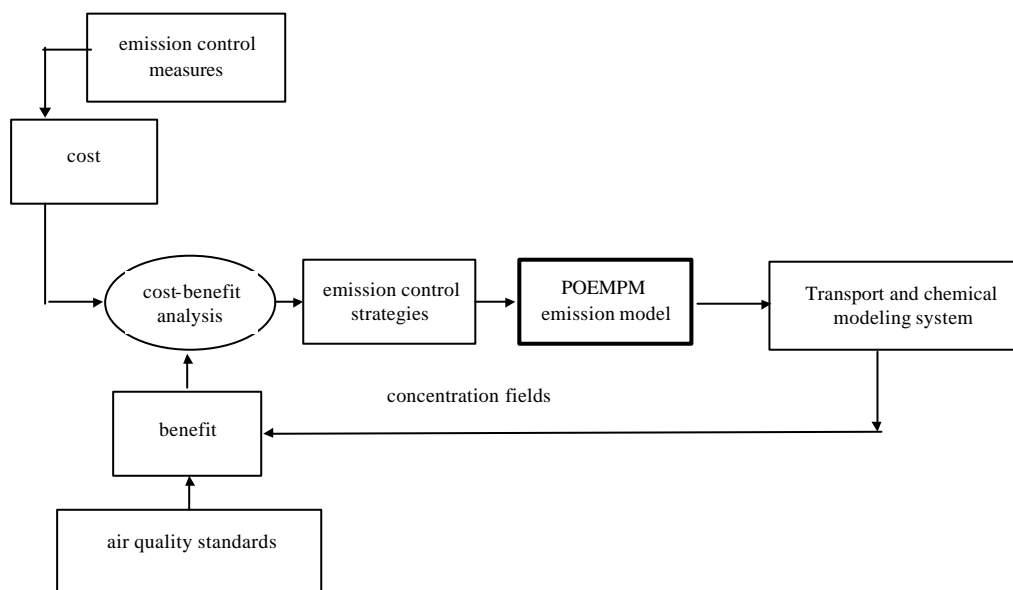


Figure 1: Decision Support System diagram

Results

POEMPM has been applied on a domain covering an area of 240x232 km^2 , including the whole Lombardia region as well as rural areas in Po Valley, the Central Alps (reaching 4000 m) and portions of Southern Switzerland (Figure 2).

Lombardia region, placed in Northern Italy, is often affected by severe particulate pollution episodes. This is due to both anthropogenic and meteorological effects. In fact Lombardia region is very industrialised and populated and it is characterised by strong urban, industrial and traffic emissions; moreover, due to the presence of the Alps, often exhibits weak circulation and stagnant conditions. Domain is characterised by a close road and highway

network, so PM emissions from road transport represent the main part of total particle emissions.

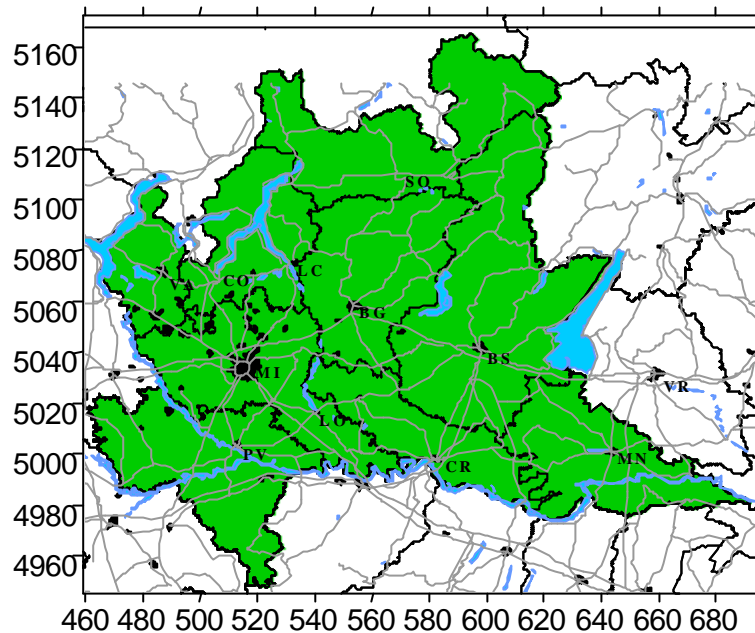


Figure 2: Computational domain used for simulation

For the estimate of road transport emission fields in the studied area a four step procedure has been followed:

- The vehicle fleet (number of vehicle and age distribution) is split in CORINAIR road traffic categories;
- The yearly national emissions have been computed for the estimated vehicle fleet by means of COPERT III;
- Emission factors, in terms of size and chemical classes, are estimated (per vehicle class, per production year, per road class and per fuel type) on the basis of experimental data provided by EURON-Agip Petroli (Carnevale et al., 2001) research laboratory;
- Total yearly emissions are both spatially and temporally resolved by POEMPM runs.

Figure 3 shows the emission field of PM₁₀ estimated for a working summer day (1st June 1998) at 07.00 pm. Results show considerable emissions between 6 am and 12 pm, a peak at 7 pm, when the traffic is more intensive. As simulation shows, emissions are concentrated near urban areas (mainly Milan metropolitan area) and main extra urban roads.

Conclusions

In this work emission model POEMPM has been presented. POEMPM structure allow to estimate emission fields of PM for all CORINAIR sources, according to different spatial and temporal resolution. The description of emitted particles in terms of size and chemical composition is also provided.

The emission model has been applied to a computational domain, including Lombardia region, in order to simulate PM emissions due to road transport.

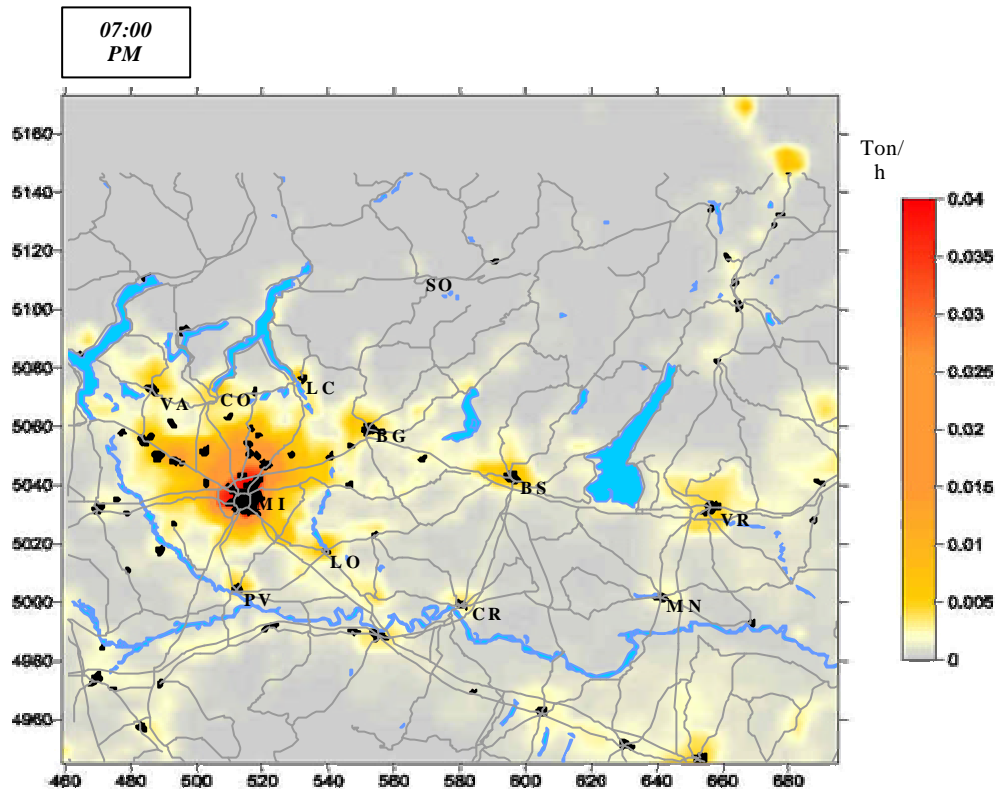


Figure 3: PM emission field estimated for 1st June 1998 (7 pm)

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