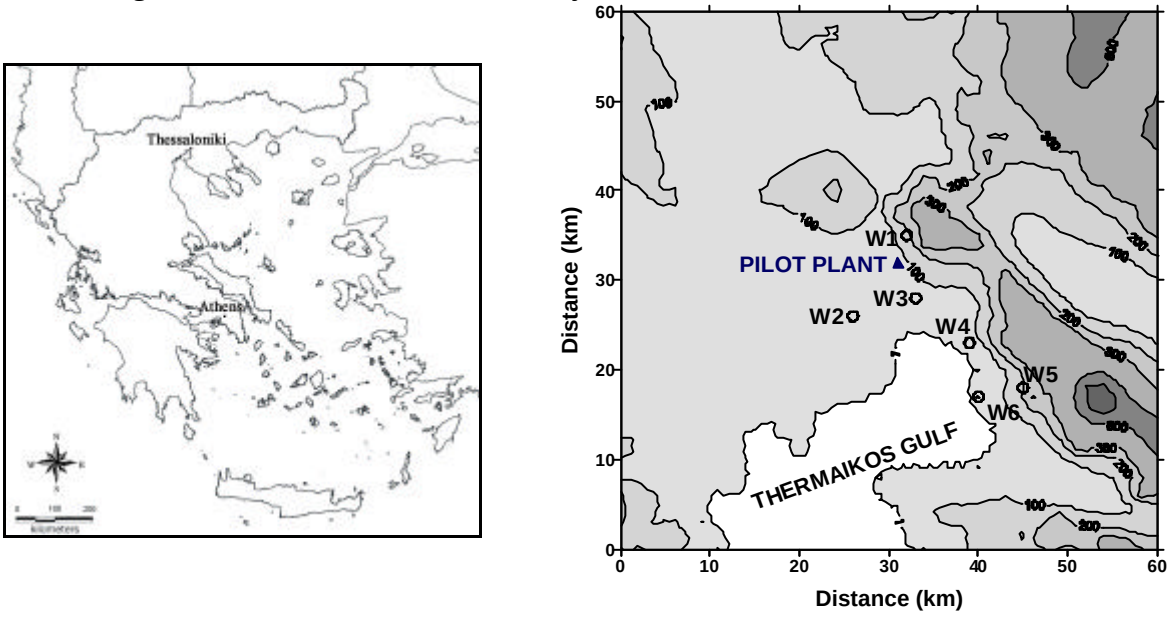
AIR QUALITY IMPACT ASSESSMENT OF A PILOT PLANT USED FOR THE TREATMENT AND STABILIZATION OF SOLID WASTES

Anastasia Poupkou[1], Dimitrios Melas[1], Georgios Kaimakamis[2], Panagiotis Kavouras[2], Thomas Kehagias[2] and Theodoros Karakostas[2]
[1]Laboratory of Atmospheric Physics, Aristotle University of Thessaloniki, Greece
[2]Laboratory for Treatment and Stabilization of Solid Wastes, Aristotle University of Thessaloniki, Greece

INTRODUCTION

The purpose of this study is the air quality impact assessment of a pilot plant that is established in order to co-melt and subsequently vitrify solid wastes, which are found in powder form or can be easily pulverised. The solid wastes are mixed and co-melted with vitrifying agents, like sand, sodium and calcium carbonates. The solid mixture, when heated at temperatures higher than 1000°C, is transformed into a homogeneous melt. This melt is poured on stainless steel surfaces and is rapidly solidified into a large piece of glass (1.0x0.5x0.2 m^3 approximately). The plant is equipped with a state of the art air pollution control technology (Spray Tower, Venturi scrubber) to remove coarse and fine particulate matter and water soluble chemical compounds from the released air wastes. The pilot plant is located about 15 km away from Thessaloniki which is the second largest urban centre of Greece (Figure 1). The plant does not operate on a regular basis and can process 150kgr of solid wastes per hour. In the present work, the vitrified solid waste was rich in lead bromide ash. The ash was produced by the incineration of sludge that was found as sediment in leaded gasoline storage tanks and it was rich in tetraethyl lead.



a) b)

Fig. 1; a) Map of Greece showing where Thessaloniki is situated, b) Modelling domain covering the Greater Thessaloniki Area and location of the pilot plant. W1 to W6 denote the locations of the near-surface wind stations.

THE MODELLING SYSTEM

The impact assessment is performed using a modelling system that consists of a diagnostic model for the calculation of the three-dimensional wind fields and a Gaussian puff model to simulate pollutants dispersion from point sources (RIsø-Mesoscale-PUFF model).

The diagnostic model

The diagnostic model used provides wind fields that satisfy the continuity equation (*Melas, D. et al., 1998*). Input data of the model are the topography, the land use and wind measurements. The model employs a terrain following coordinate system. The wind field computation, at user defined levels, follows two steps. Firstly, a three-dimensional wind field is estimated based on wind measurements and using an interpolation method. Afterwards, this field is slightly modified in order to satisfy the continuity equation.

The dispersion model

RIM PUFF is a three-dimensional Langrangian mesoscale atmospheric dispersion puff model designed for calculating the concentration resulting from the dispersion of airborne materials (*Thykier-Nielsen, S. et al., 1999*). The model applies both to homogeneous and inhomogeneous terrain with moderate topography and responds to changing meteorological conditions. The core of the model consists of an algorithm that models a time-varying continuous release by a series of consecutively released Gaussian shaped puffs at a fixed rate on a specified grid. At each time step the model advects, diffuses and deposits the individual puffs according to local meteorological parameter values. The model calculates the concentration at each grid point by summing the contributions from surrounding puffs at each advection step.

MODELLING SYSTEM SET UP - INPUT DATA DESCRIPTION

Model simulations were performed for a 60 x 60 km^2 domain covering the Greater Thessaloniki Area (Figure 1). The modelling domain was covered by 61x61 grid points having 1 km horizontal spatial resolution. There were 10 vertical layers extending from surface to approximately 3 km agl. The vertical layers were unevenly distributed with higher resolution at the near-surface layers. The modelling system was implemented for the year 2003 considering a 1-day spin up simulation period. For the application of the diagnostic model, hourly wind data from six near-surface wind stations of the air quality network of the Hellenic Ministry for the Environment, Physical Planning and Public Works were used (Figure 1). RIM PUFF model was used to simulate the dispersion of four pollutants emitted from the pilot plant stack: 1) Particulate Matter (PM) (diameter = 5μm), 2) Sulphur dioxide (SO_2), 3) Lead (Pb) and 4) Cadmium (Cd). The release height was 15 m.

The estimation of the pollutants emission rates was based mainly on the chemical composition of the processed wastes, the mean hourly activity rate of the plant and the efficiency of the air pollution control system (considered to be 85% and 99% for the Spray Tower and the Venturi scrubber respectively). Air pollutants concentrations were calculated for two emission scenarios assuming continuous operation of the plant during the year 2003. In the first emission scenario the air pollution control system was operating while in the second scenario was not. Model results were recorded on an hourly basis. Ground level model results were compared to the European Union air quality limits for the protection of human health (table 1).

RESULTS AND CONCLUSIONS

1st emission scenario: Air pollution control system is operating

Figure 2 shows the spatial distributions of the pollutants simulated concentrations. EU air quality limits for PM_{10}, SO_2 and Pb are not exceeded. The EU annual limit value for Cd (to be met though by 31/12/2012) is exceeded only at the stack area where annual Cd concentration is in the order of 5.9 ngr/m^3. However, at more than 1 km distances from the source, Cd concentrations are sharply reduced becoming less or equal to 1 ngr/m^3. It should be also

noticed that the estimated emission rate of Cd from the pilot plant stack represented a worst case release rate.

Table 1. Air quality limit values in the ambient air (Directives 1999/30/EC and 2004/107/EC)

Pollutant	Averaging Period	Limit value (Date by which limit value is to be met)	Indicative limit values for the years 2006/2010
PM_{10}	24 hours	50 μg/m^3, not to be exceeded more than 35 times a calendar year (1/1/2005)	
	Calendar year	40 μg/m^3 (1/1/2005)	36 / 20 μg/m^3
SO_2	1 hour	350 μg/m^3, not to be exceeded more than 24 times a calendar year (1/1/2005)	
	24 hours	125 μg/m^3, not to be exceeded more than 3 times a calendar year (1/1/2005)	
Pb	Calendar year	0.5 μg/m^3 (1/1/2005)	
Cd	Calendar year	5 ng/m^3 (31/12/2012)	

2nd emission scenario: Air pollution control system is not operating

Figure 3 shows the spatial distributions of the pollutants simulated concentrations. The EU 24-hour and annual limit values for PM_{10} and the annual limit value for Pb are exceeded only at the area where the stack is located. The EU 24-hour limit value for PM_{10} is exceeded 85 times during 2003. EU air quality limits are not exceeded for SO_2. The EU annual limit value for Cd (to be met though by 31/12/2012) is exceeded at distances up to 9 km away from the stack, affecting residential areas. The previous results suggest that the air pollution control system is absolutely necessary to operate in order the air quality limit values for the protection of human health not to be exceeded in the modelling domain.

ACKNOWLEDGEMENTS

This work was co-funded by the European Social Fund and National resources, through the "PYTHAGORAS" program.

REFERENCES

Melas, D., I. Ziomas and I. Kioutsioukis, 1998: Real time calculation of the dispersion of air pollutants from industrial stacks using a personal computer. Fres Env Bul, 7, 134-140.

Thykier-Nielsen, S., S. Deme and T. Mikkelsen, 1999: RIMPUFF Atmospheric Dispersion Model, User's Guide, version: RIMDOS8, rev. 29. Department of Wind Energy and Atmospheric Physics, Risø National Laboratory, Roskilde, Denmark.

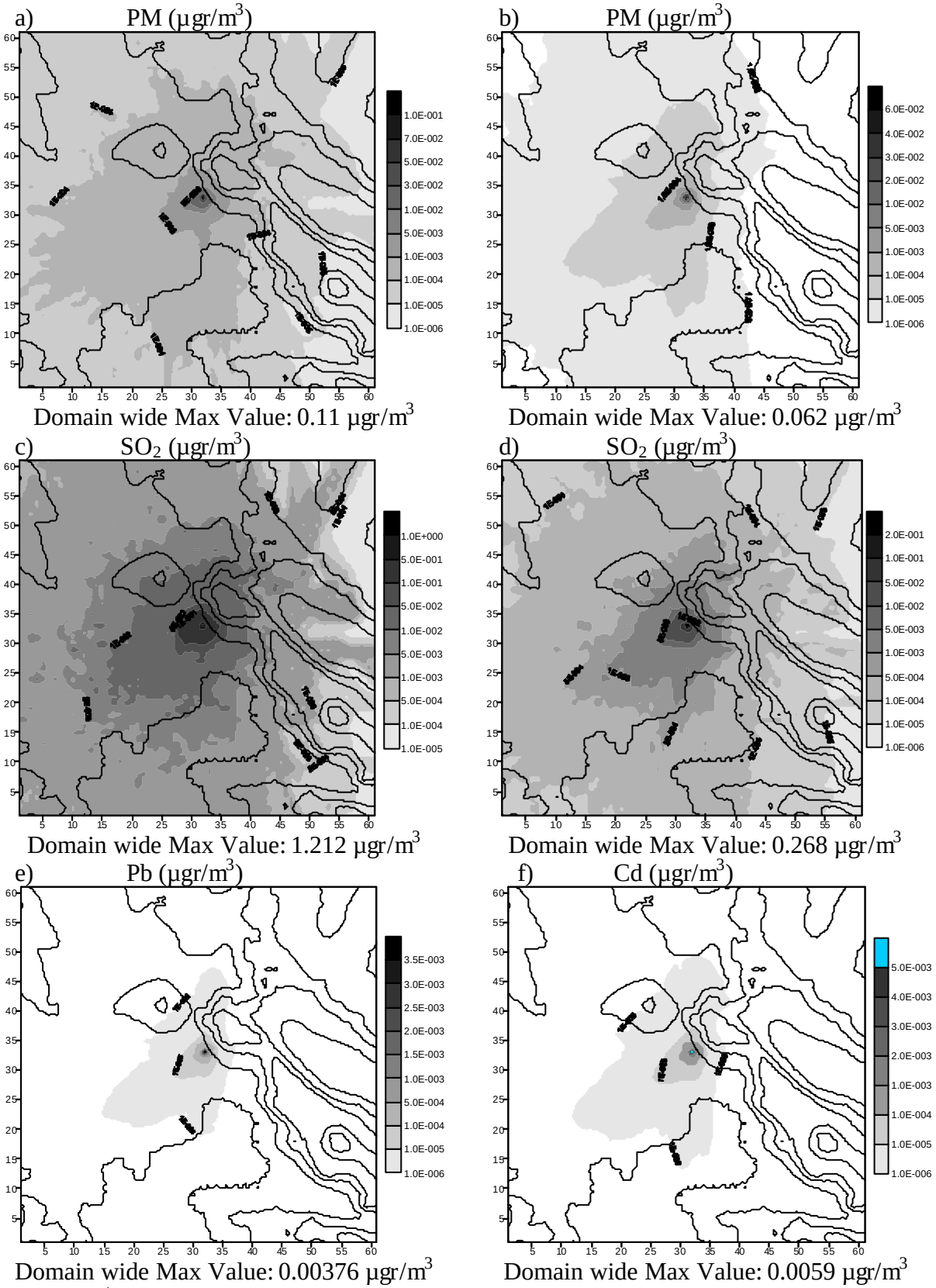


Fig. 2; 1st emission scenario: Spatial distribution of a) maximum daily PM concentrations, b) annual PM concentrations, c) maximum SO_2 concentrations, d) maximum daily SO_2 concentrations, e) annual Pb concentrations and f) annual Cd concentrations for the year 2003.

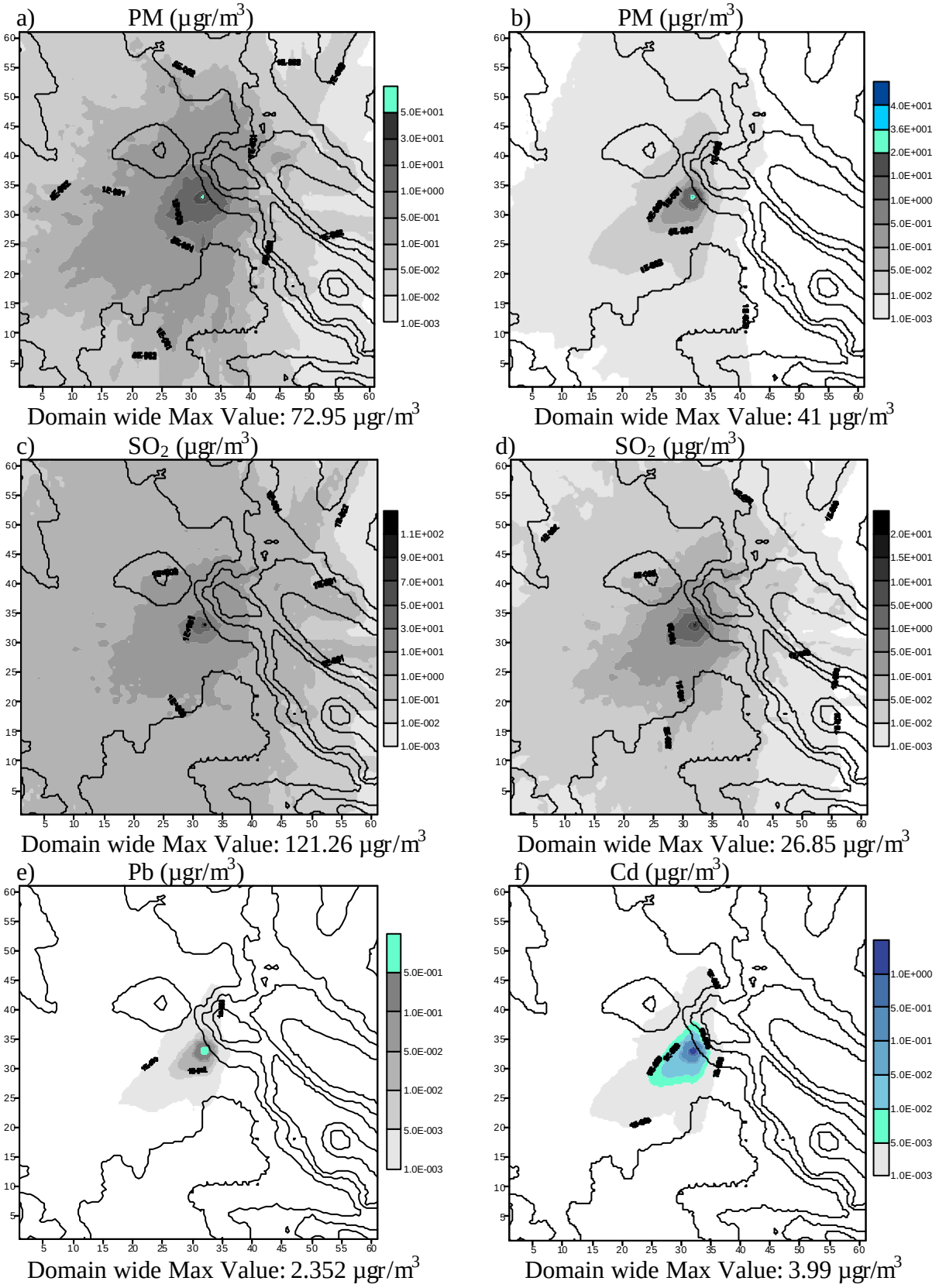


Fig. 3; 2nd emission scenario: Spatial distribution of a) maximum daily PM concentrations, b) annual PM concentrations, c) maximum SO_2 concentrations, d) maximum daily SO_2 concentrations, e) annual Pb concentrations and f) annual Cd concentrations for the year 2003.